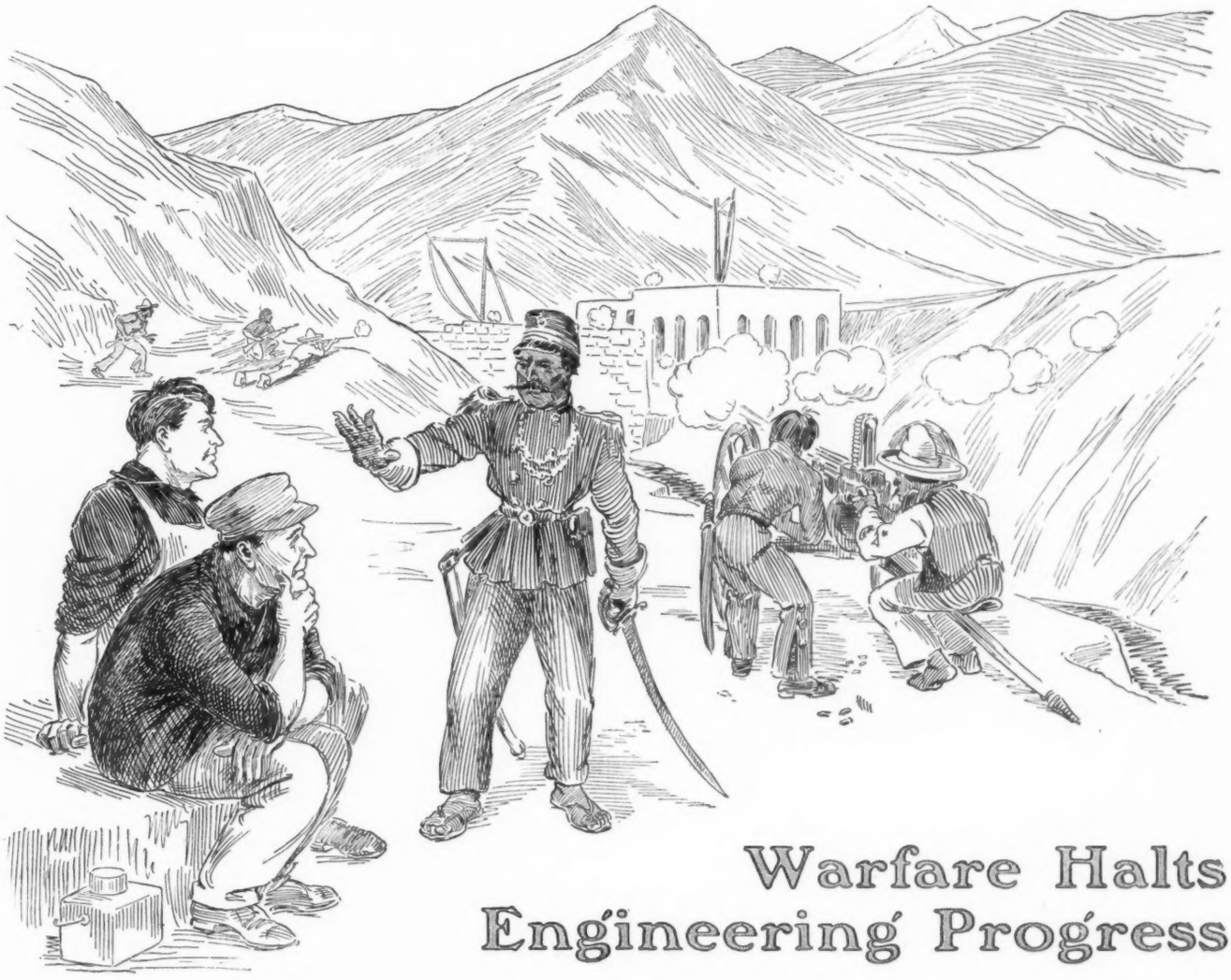
POWER

Vol. 39 NEW YORK, APRIL 28, 1914 No. 17

The Pity of It!



Warfare Halts Engineering Progress

"* * * As a result, the directors have unanimously decided to drop all further operations until the political disturbances affecting the company's works have ceased. Under the prevailing conditions it is impossible to transport to the dam the necessary supplies to complete the work. Practically the entire staff has therefore been released, retaining only a few men strictly necessary to safeguard the property. The dam has reached an elevation of 144 ft., and the reservoir is now filled with water to an elevation of nearly 121 ft. The power house is practically completed and much of the machinery installed."

—Extract from a recent news clipping.

Chicago Federal Building's Plant

By Thomas Wilson

SYNOPSIS—The addition of a 600-kw. generating plant to an equipment of boilers, elevators and compressed-air machinery effected a saving in operating expense of $1700 for the month of March. For the year, the saving should total over $14,000.

In these columns mention has been made of the decision to install in the Chicago Federal Building a generating plant to supply the current for light and power then furnished by the Commonwealth Edison Co. Since its inception in 1905, the building had been equipped with a boiler plant to supply steam for hydraulic elevator pumps, engine-driven air compressors serving a pneumatic tube system, for boiler-feed and other pumps and for the heating system. The exhaust from the units just mentioned only supplies about half the heat requirements of the building in the colder weather, so that a great deal of live steam was needed. The advantage of passing this steam through an engine cylinder before delivering it to the heating system was recognized, and the investigation was started which resulted in the installation of the present plant.

From the first month's operation, all expectations have been met and the results will be still better when the plant has been run long enough to be operated at its highest efficiency. For a total expenditure of $43,000, including an addition to the switchboard, steam piping and all new equipment, a saving has been effected in the operating expenses of fully $1700 for the month of March, as compared with last year's records. In the colder months this saving should be more, and in the summer months less, but a conservative estimate would be a gain of $12,000 to $15,000 per year, so that the generating plant will pay for itself in a period of three or four years.

Before taking up the records in detail it may be of interest to outline briefly the equipment of the plant. The building itself is of granite construction, covering in plan a city block. Part of it is three stories high; this increases to eight and then to sixteen stories at the center. The top of the dome is 360 ft. above the street level. The building has a total of 740,000 sq.ft. of floor space and houses practically 10,000 employees distributed be-

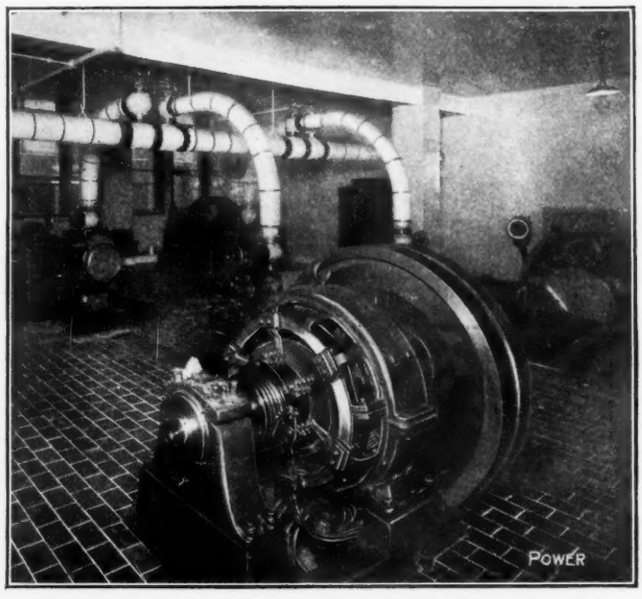


Fig. 2. The Four Generating Units

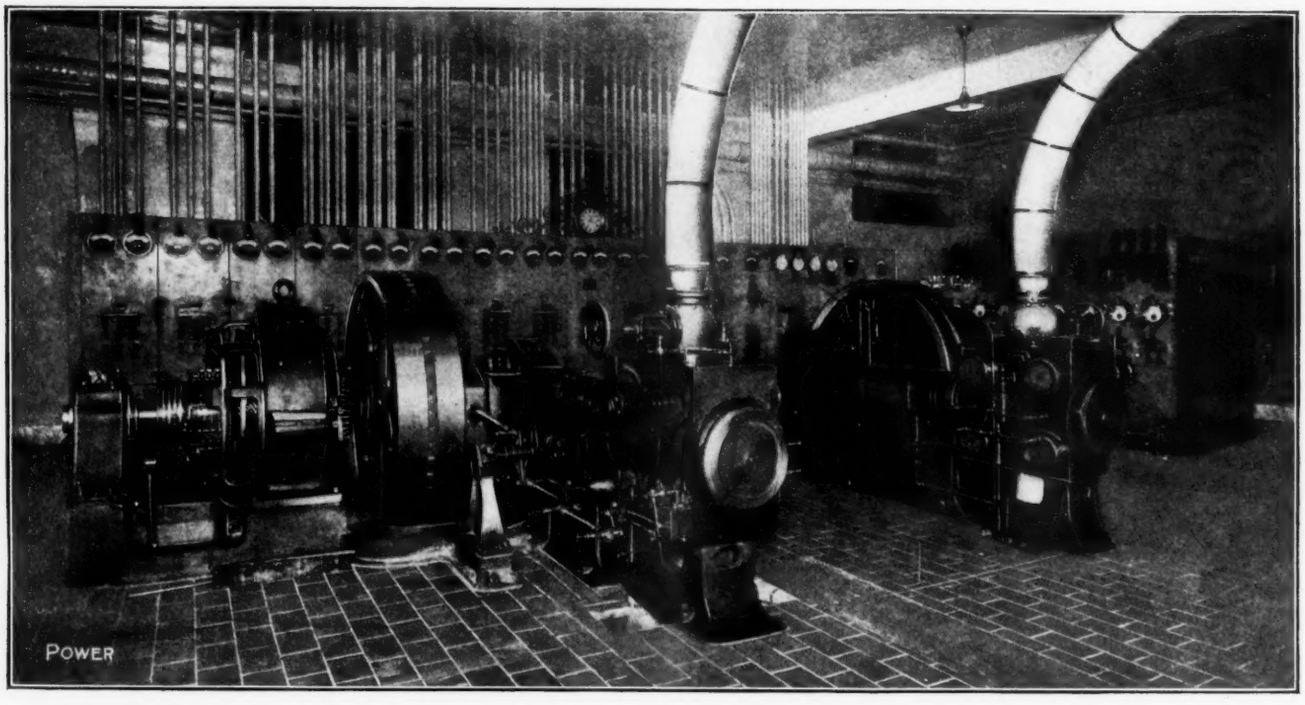


Fig. 1. The Two Smaller Units and the Switchboard

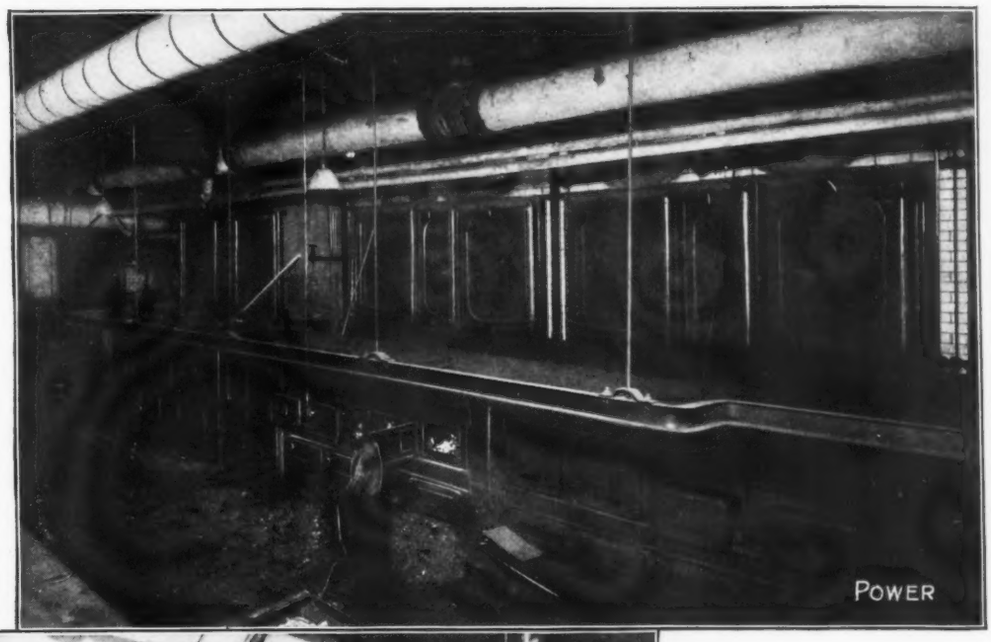


FIG. 3. THE FIVE 350-HP. BOILERS.

FIG. 4. THE THREE ELEVATOR PUMPS

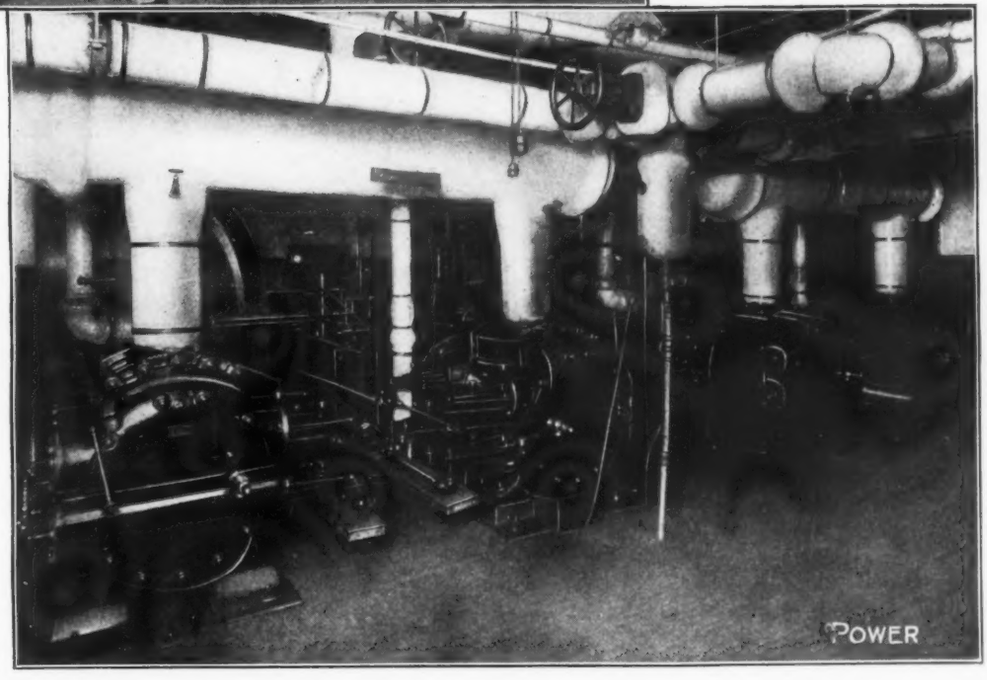


FIG. 5. TWO OF THE CROSS-COMPOUND COMPRESSOR UNITS

tween 45 departments. It is heated by 45,000 sq.ft. of indirect and 65,000 sq.ft. of direct radiation supplied with steam by a two-pipe Webster vacuum system equipped with three 10 and 16 by 12-in. vacuum pumps. The condensation is returned to a 900-gal. receiving tank, from which it is fed to a 5000-hp. Webster feed-water heater, then to a Green economizer provided with 144 four-inch tubes 12 ft. long, and finally to the boilers by two outside-packed plunger pumps, one 12 and 7 by 10 in. and the other 10 and 6 by 10 in. During the heating season the makeup amounts to about one-third of the boiler feed. The temperature is raised to about 200 deg. in the heater and to approximately 250 deg. in the economizer.

There is ample boiler capacity, as the plant has five 350-hp. units of the Aultman & Taylor water-tube type, each containing 2928 sq.ft. of heating surface and 54 sq.ft. of grate surface in a Hawley down-draft furnace. The working pressure allowed is 165 lb. gage, but in operation it averages about 155 lb. Illinois washed nut coal averaging about 12,000 B.t.u. per lb., and at times less, is burned. This is stored in a 380-ton bunker under the sidewalk and is conveyed in industrial railway cars to the boiler room, where it is dumped into the firing pit and is shoveled into the furnaces. The ashes are removed by a monorail-bucket system and raised into wagons by an ash hoist. Originally, the stack only extended through the roof of the eight-story section of the building, but was later carried to the top of the dome and is now 360 ft. high. It is square in section and, due to numerous turns and to the economizer, a draft of only 0.8 in. at the base is available. During the winter months three boilers have carried the load, and before the generating units were installed one boiler was sufficient during the summer.

Seven Otis passenger elevators of the inverted type and of 3000 lb. capacity serve the building. There are also four 4000-lb. freight elevators and four 2000-lb. hydraulic lifts to the second story. The equipment is served by one Laidlaw-Dunn-Gordon pumping engine, 16x20x20x5¼x24 in., and two duplex tandem-compound pumps, 16x25x7x⅜x18 in., which work against a water pressure of 750 lb. maintained uniformly by an accumulator having a 10-in. ram weighted with 42 tons of cast iron.

For the pneumatic-tube mail-handling system there were installed four Ingersoll-Rand compressors driven by cross-compound engines ranging in capacity from 75 to 125 hp. A 20-ton Carbondale absorption plant cools the drinking water. The exhaust from the circulating and aqua ammonia pumps is sufficient for the absorption system so that it is only necessary to supply live steam to the pumps.

To this equipment the boiler plant supplies steam. Besides some miscellaneous machines, such as four Westinghouse air pumps, two small air pumps on the thermostatic temperature-regulating system, a vacuum cleaner, etc., take more or less live steam. An enormous quantity of hot water is required. This is heated in three 500-gal. tanks provided with coils supplied with exhaust steam.

The steam to the elevator pumps and the compressor engines of the pneumatic-tube system is measured by General Electric flow meters. The water to the boilers is also metered, and even the blowoff is measured, so that it has been possible to divide the steam consumption between the elevators, compressors and the heating system, the last-named, including the pumps and the miscellaneous apparatus in the plant, taking live steam. A flow meter has just been installed for the generating units, so that this department may also be credited with its proper steam consumption.

Exhaust from the various machines mentioned is supplied to the heating system, but before the engines were installed the supply was far short of the heat requirements. It was necessary to use a large quantity of live steam reduced to atmospheric pressure to conform with the pressure existing in the vacuum system.

The generating plant consists of two 200-kw. and two 100-kw. units made up of Harrisburg Foundry & Machine Works four-valve engines and Westinghouse three-wire, 125-250-volt generators. Each of the smaller engines has a cylinder measuring 14x15 in., and the cylinders of the larger engines are 17x20 in. The speeds are 250 and 200 r.p.m. respectively. As the meter for the engines was not installed during the month of March, no records of steam consumption in the plant are available, but the results obtained at the works for one of the smaller units are given in Table 1, and in Table 2 for a 200-kw. unit. To the smaller engine steam was supplied at 137.37 lb. gage, quality 97 per cent., and the exhaust was at atmospheric pressure. It will be noticed that the engine exceeded the guarantee in each case, and at its most economical load, three-quarter, developed an indicated horsepower-hour on 19.88 lb. of dry steam.

TABLE 1. RESULTS OF TEST ON 100-KW. UNIT

Load	¼	½	¾	Full	1¼
Guarantee, lb. per kw.-hr....	59.6	37.3	33.5	33.2	34.2
Actual, lb. per kw.-hr.....	45.98	34.51	32.03	32.47	33.7
Dry steam per i.hp.-hr., lb...	25.1	21.02	19.88	20.35	21.03

TABLE 2. TEST RESULTS OF 200-KW. UNIT

Load	¼	½	¾	Full
Guarantee, lb. per kw.-hr.....	58.3	37.1	33.3	32.8
Actual, lb. per kw.-hr.....	41.6	31.67	30.43	32.04
Dry steam per i.hp.-hr., lb.....	25.1	19.9	19.4	20.6

In Table 2 it is shown that the steam consumptions of the 200-kw. unit obtained by test are considerably below the guarantees. At three-quarter load the rate per indicated horsepower-hour is 19.4, and it will be noticed that the steam taken at one-half, three-quarter and full loads is very nearly the same. In this test the steam pressure averaged 141.5 lb. gage and the quality 99 per cent.

Table 3 gives the operating records of the plant from April, 1912, through March of the present year. Data for this period of time are given to show how the load varied for the different seasons of the year, and so that the corresponding months of the two years covered might be compared. From the records of coal consumption and kilowatt-hours per month it is evident that the load is gradually increasing, due to the greater bulk of mail handled by the post office. No cost figures, except the monthly sums paid the Edison Co., are given, but from the following data, the operating cost may be easily approximated.

During 1913 the price of coal per long ton averaged $3.10 and for the three months of 1914 it has averaged about $3.06, the grade being inferior to the coal used last year. Labor and supplies approximated $2000 per month. Water cost 52.5c. per 1000 cu.ft. and the electric rate for power and light was based on a sliding scale ranging from 1.7 to 1.9c. For anything over 100,000 kw.-hr. per month the rate was reduced to 0.9c. Dividing the price paid in 1912 by the total kilowatt-hours

TABLE 3. OPERATING DATA OF PLANT, COVERING A PERIOD OF TWO YEARS

Year	Month	Deg.-Hr. per Mo. below 70°	Deg.-hr. per Day below 70°	Av. Temp. Feed Water from Heater Deg. F.	Av. Temp. Feed Water from Econ. Deg. F.	Steam Supply: Av. Steam Press. Lb. Gage	Av. Evap. per Lb. Coal	To Elevat. or Pumps, Lb.	To Pneumatic Tube Compressor Engines, Lb.	To Pumps and Heating System Lb.	Blowdown Water, Lb.	Total Steam per Mo., Lb.	Av. Steam per Day Lb.	Central Station Current: Power Kw.-Hr. per Mo.	Light Kw.-Hr. per Mo.	Total Kw.-Hr. per Mo.	Av. Kw.-Hr. per Day	Cost Current per Mo.	Coal: Coal per Mo. Long Tons	Coal: Av. Coal per Day, Long Tons
1912	April	15,000	500	160	247	156	7.7	1,599,284	1,799,236	3,634,770		7,033,297	234,443			104,090	3469	$1980.98	406	13.53
1912	May	9,196	296.6	166	248	157	7.1	1,501,227	1,385,113	2,132,994		5,019,334	161,914			102,850	3318	1987.07	316	10.20
1912	June	3,552	118	196	249	155	6.7	1,487,888	1,362,892	1,207,042		4,057,823	135,261			114,140	3804	2113.31	269.65	9.00
1912	July	1,000	32	200	250	153	7.8	1,391,374	1,430,154	3,061,293	116,203	5,999,024	193,517			117,160	3779	2088.19	278.3	8.98
1912	Aug.	1,752	56.5	204	251	157	9.6	1,473,237	1,275,730	2,823,987	128,116	5,701,070	183,905	50,470	69,760	120,230	3878	2056.60	259.11	8.36
1912	Sept.	4,176	139	191	250	156	9	1,459,351	1,300,076	2,669,118	124,950	5,553,495	185,116	49,020	68,070	117,090	3903	2129.33	275.46	9.18
1912	Oct.	10,050	324	159	245	157	8.2	1,497,175	1,466,499	3,334,573	129,115	6,427,362	207,334	47,680	78,020	125,700	4055	2172.21	352	11.3
1912	Nov.	19,616	653.8	151	237	157.4	7	1,584,140	1,254,515	4,564,113	124,950	7,527,718	250,924	43,060	74,150	117,210	3907	2216.56	474.8	15.83
1912	Dec.	27,586	889.8	117.7	236.1	157.3	6	1,614,141	1,491,888	5,194,755	129,114	8,429,898	271,932	39,910	83,130	123,040	3969	2298.43	619.07	19.97
1913	Jan.	40,240	1298	181	247.2	157.8	7.3	1,686,395	1,242,659	7,778,382	129,115	10,836,581	349,567	40,760	86,610	127,370	4109	2316.55	655.65	21.15
1913	Feb.	30,312	1082.5	187.8	249.1	156.9	7.4	1,799,082	1,010,185	7,631,197	116,620	10,557,084	377,039	25,550	76,110	101,660	3631	2055.63	630.6	22.5
1913	Mar.	26,090	841.6	187	248	156.9	7.1	1,808,995	1,278,115	6,282,729	129,115	9,498,954	306,418	26,130	84,210	110,340	3559	2067.60	587.75	18.96
1913	April	15,336	511	179.9	244.9	156.2	7	1,778,109	1,171,217	3,851,117	124,950	6,925,393	230,846	27,690	80,380	108,070	3602	1912.91	433.82	14.46
1913	May	9,336	301	196.3	245.7	156.5	7.4	2,021,948	1,506,844	2,354,873	129,115	6,012,780	193,961	35,340	79,220	114,560	3695	2007.26	352.8	11.4
1913	June	3,932	131	197	246.6	157	7.8	1,679,797	1,779,345	1,374,225	124,950	4,958,317	165,277	36,310	72,000	108,310	3610	1926.31	281.95	9.39
1913	July	576	18.5	192.6	242.7	157.6	7.1	1,732,052	1,872,207	1,455,242	103,292	5,160,793	166,477	39,090	70,790	109,880	3544	2036.87	315.95	10.19
1913	Aug.	432	14	206.8	246.8	157.1	7.2	1,883,808	1,405,634	1,602,891	77,469	4,969,802	160,316	41,560	70,010	111,570	3599	1936.32	302.35	9.75
1913	Sept.	5,470	182.3	189.4	251	157	8	1,936,532	1,152,609	2,926,153	126,616	6,141,910	204,730	61,440	72,310	133,750	4458	2054.89	336.8	11.23
1913	Oct.	12,897	416	174.2	249.1	157.6	7.3	1,853,233	1,468,586	3,600,408	103,292	7,025,519	226,630	74,280	84,940	159,220	5136	2190.06	419.95	13.55
1913	Nov.	16,488	549.6	169.6	242.3	157	7.0	1,872,223	1,114,177	4,128,980	99,960	7,215,340	240,511	65,560	82,380	147,940	4931	2221.30	456	15.2
1913	Dec.	26,136	843.1	165.2	236.8	156.6	6.8	2,013,413	1,175,216	5,573,421	103,292	8,865,342	285,979	54,000	93,990	147,990	4774	2270.78	576.04	18.58
1914	Jan.	27,888	886.7	164.5	232.6	157.6	7.7	1,929,707	1,203,562	8,449,826	103,292	11,686,447	376,982	46,080	93,180	139,260	4492	2206.90	673.85	21.74
1914	Feb.	38,480	1495	177.2	243.9	157.8	7.3	1,800,900	798,549	9,418,885	93,296	12,111,630	432,558	36,970	81,810	118,780	4242	2026.55	733.72	26.2
1914	March	25,384	818.8	182.2	248.8	154.5	6.7	2,045,846	970,536	7,025,645	103,292	10,745,319	346,623	45,460	89,880	135,340	4366		713	23

supplied gave exactly 1.9c., and for the past year the rate figures nearly the same.

Without any records of steam taken by the generator units, perhaps the best way to arrive at a conclusion on the saving effected is to compare the total costs of operating the entire plant for the months of March in 1913 and in 1914, the latter month being the first for the generating plant. Reference to Table 3 will show that the degree-hours below 70 deg. are very nearly the same; March of 1913 is only 706 deg.-hr. colder. In March of 1914 more steam was used by the elevators, less by the compressor engines, more by the pumps, engine units and the heating system, so that, as shown in the totals, the excess for this year is considerably over 1,000,000 lb. The kilowatt-hours for the months are also greater by 25,000 and the coal consumption 125 tons more. By a readjustment of the existing force only two additional men were needed for the generating plant, adding $166 to the pay roll. The plant is run on three 8-hr. shifts.

For March of 1913 the operating expense, including current, coal, water, labor, supplies and repairs, totaled $5995.59. For March of 1914 the total was $4519.91. The difference is just $1475.68, notwithstanding the additional coal, steam, labor and the 25,000 kw.-hr. in excess of last year's figure. Charging this at 0.9c. per kw.-hr., the Edison bill for March of 1913 for an equal output would be increased $225, so that the total saving effected in the operating expenses would be $1700.

It might be remarked that the steam pipes to the engines were uncovered for the greater part of the month, and in order to tune up the different units, more of them were kept in service than was required by the load. As usual in starting up, the consumption of oil was excessive and the friction greater than ordinary. As time goes on, the engines should operate more efficiently. In the summer months the saving will be less; an estimate places it at $600 per month. On the other hand, the months colder than March should show a saving of more than $1700, and it must also be remembered that more steam has been furnished to the other departments.

Taking these things into account, a fair average for six months of the year should be about $1800 and $600 for the other months. The gross annual saving would then be $14,400. The extra labor, coal, supplies, etc., have already been included, so that the interest on the investment and depreciation are the only remaining factors to be deducted from the total saving in operating expense. For these items 10 per cent. is a fair charge on the $43,000 investment covering all of the new equipment. This amounts to $4300, and deducted from the gross, leaves a net saving of $10,100, equivalent to interest of 23.5 per cent. on the investment, which is not bad, and it would be difficult to obtain a higher rate except in plants operating under similar conditions.

C. M. Peterson is chief engineer of the plant.

Two of the Most Recent Types of Oerlikon Steam Turbines are now running in the central electric station of Stockholm, these being of 10,000 hp. size. Turbine and dynamo make up a compact group, and the turbines are of a new design, which is claimed to have a number of advantages, one of these being a low steam consumption of 7.9 lb. per hp.-hour. The turbines operate at 3000 r.p.m. standard speed. Such turbines are made up as usual of blade wheels, each in a separate steam chamber, but the combination of speeds and pressures within the turbine is based on a somewhat novel theoretical design.

Synchronous Converters and Their Operation--II

By Eric A. Lof

SYNOPSIS—Various transformer connections for rotary converters, methods of starting and shutting down, and precautions to be observed. The characteristics and voltage ratios of rotary converters were discussed by the author in the April 21 issue.

Transformer Connections: On account of the low alternating voltage which must be applied at the collector rings of a synchronous converter, it is usually necessary to provide transformers for stepping down the voltage of the supply circuit.

Both oil-cooled and air-blast transformers are used, and these in turn can be either of the single-phase or polyphase type. The single-phase type, however, is used almost exclusively, although in certain installations three-phase transformers may be found.

A separate transformer bank for each synchronous converter is preferable, as an entire unit can then be operated independently and a more flexible and reliable system obtained, also, the converters are less sensitive, the reactance of the transformers affording some flexibility between the converters, regarding field excitation, etc. If several converters were operated from the same transformer bank, the failure of any transformer would cripple the whole system. Moreover, the single transformer bank would have to be large enough for all the converters under maximum service conditions, while ordinarily it would be operating only at a fractional load and a correspondingly low power factor.

The voltage ratio of the transformers should be such as to give full-load secondary voltage corresponding to the full-load converter voltage. Primary taps should be provided for changing the ratio of transformation so as to keep the secondary voltage the same, should the voltage of the supply circuit change, due to additional load.

Starting taps are brought out from the secondary windings of the transformers and these taps are generally located at the middle points of the windings, for supplying three-phase converters, so as to give the machine one-half rated voltage for starting. For converters of 500 kw. and above, which are mostly of the six-phase type, two taps are provided in the transformer secondaries, located at respectively one-third and two-third points. Thus when connected to the first tap at starting, the converter will receive one-third normal voltage and when connected to the second it will receive two-thirds.

The diagrams shown in Figs. 7 to 12 represent various methods of connecting transformers and converters. The large circle in each diagram is assumed to represent the armature winding of a converter, the collector rings being omitted for simplicity. Fig. 7 shows the connections for a quarter-phase converter, the two terminals of each transformer secondary being connected to the converter winding at points 180 deg. apart. If the machine is to be used for supplying current to an Edison three-wire system, the neutral can be connected to the middle taps indicated in the secondary windings.

Fig. 8 represents a three-phase, delta-connected system with the transformer terminals connected to the converter winding at points 120 deg. apart. No neutral point can be obtained with this connection.

Fig. 9 represents a three-phase, star-connected system. Three corresponding transformer terminals are joined together, forming a neutral point, while the other terminals are connected to the converter winding at points 120 deg. apart. For three-wire service the neutral may be brought out, but it is important that the secondary windings be arranged so as to give good mutual induction in order to avoid shifting of the neutral due to unbalanced current. Arrangements should also be made with this system for opening the neutral connections during starting to avoid a short-circuit. The neutral connection should not be used for a three-wire direct-current system if the unbalanced direct current is large.

Transformers for star-star connection should be insulated for double-line voltage to ground and three times normal leg voltage across the windings. When so insulated there is no objection to the use, with converters, of transformers connected in this manner, and it is unnecessary to specify that the neutral must be grounded. This does not, however, necessarily apply to transformers for high-voltage transmission. There may be other problems involved which would make it undesirable to use the transformers connected in this way.

A so called "zig-zag" system of connections, as shown in Fig. 10, has been devised to eliminate the flux distortion, due to large unbalanced direct currents of a three-wire system. The winding consists of two coils on each leg, cross-connected as shown. The flux due to one coil in each leg will neutralize that due to the other coil on the same leg, and the only flux in the core will be that due to the alternating magnetizing current.

Six-phase synchronous converters can be supplied by transformers connected, as in Figs. 11 and 12. The diametrical connection, Fig. 11, is used most frequently as it requires only one secondary coil on each transformer. The middle points can be connected together and a neutral obtained, the unbalanced three-wire direct current having no distorting effect. With diametrical secondaries, the primaries should preferably be connected delta except with regulating-pole converters, where they must be connected in star. In such a case, the windings must be insulated for double-line voltage to ground and three times normal leg voltage across the windings, the same as for star-star-connected transformers.

Method of Starting

There are two common ways of starting a synchronous converter, from the alternating-current side and from the direct-current side.

Alternating-Current Starting: This consists in applying alternating current direct to the armature windings at a reduced voltage obtained from partial voltage taps on the low-tension side to the step-down transformers. After the machine has reached synchronous speed

and the right polarity has been obtained, normal voltage is applied. This method of starting is by far the best on account of its simplicity and reliability; no synchronizing is necessary and the time taken to put the machine in service is a minimum. Under normal conditions it takes about one minute to get the machine into service, but several instances are on record in which the time consumed was about 20 sec.

Two-phase machines are usually started by means of one-third and two-thirds voltage taps on the transformers and require two double-pole, double-throw switches. Three-phase machines are started from one-half voltage taps and require one double-pole, double-throw switch. Six-phase, diametrically connected machines are started from one-third and two-thirds voltage taps and require two triple-pole, double-throw switches.

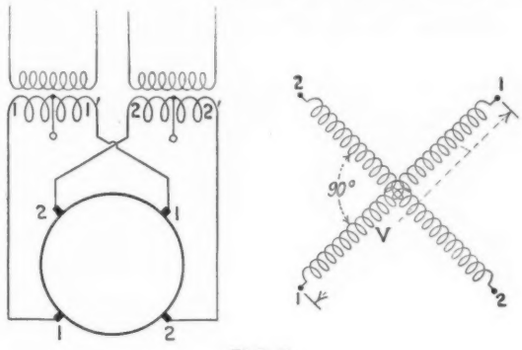


FIG 7

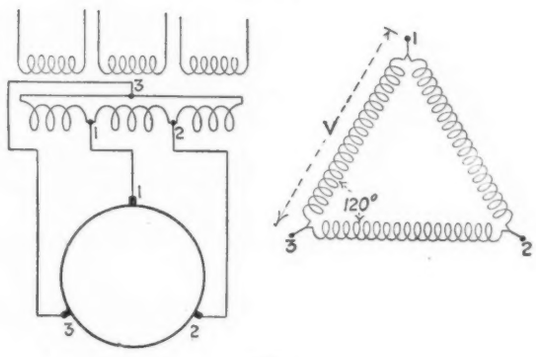


FIG 8

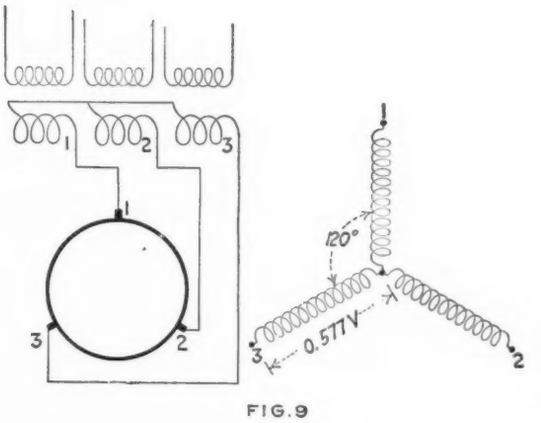


FIG.9

DIRECT-CURRENT STARTING: When direct current is available a machine can be started as a direct-current motor and synchronized on the alternating-current side. The only advantage of this method is the smaller amount of power required from the line to start. It has the disadvantage of taking considerable time, and there is danger of closing the circuit when the machine is out of phase, which might result in the shutting down of the entire system.

STARTING BY INDUCTION MOTOR: This method consists of starting by means of an induction motor mounted on an extension of the converter armature shaft. It possesses the disadvantages of direct-current starting, with the additional disadvantages that the starting motor often occupies valuable space, increases the cost of the machine, and there is a slight loss of efficiency on account of the constant windage loss of the starting motor.

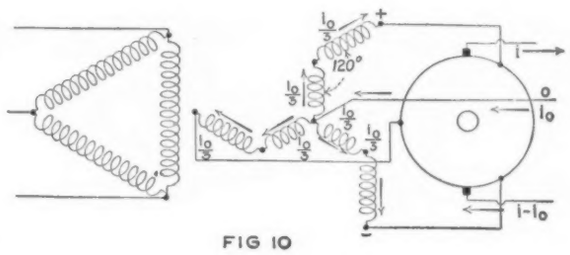
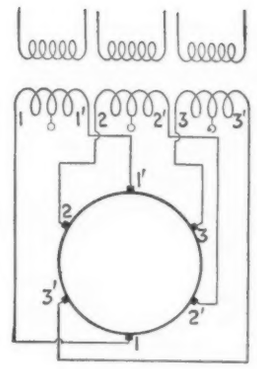


FIG 10



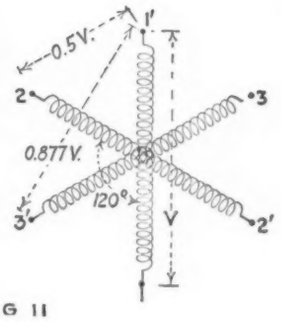
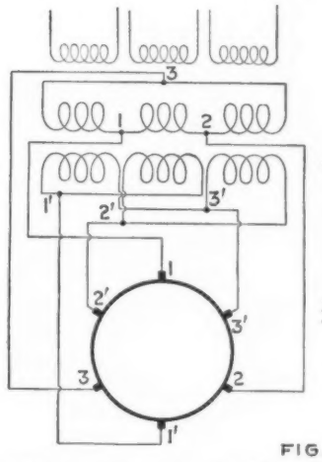


FIG 11



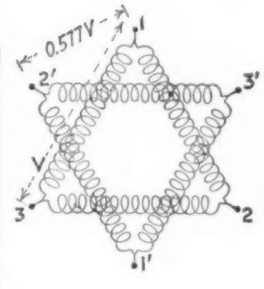


FIG.12

DIFFERENT METHODS OF CONNECTING TRANSFORMERS AND ROTARY CONVERTERS

COMBINATION ALTERNATING- AND DIRECT-CURRENT STARTING: When direct current is available a combination of direct- and alternating-current starting can sometimes be used to advantage. The machine is started from rest by direct current, and after the direct current has been shut off it is thrown on the lowest voltage taps used

for alternating-current starting. This method is used by two or three large companies with success.

Switching

The switching equipments furnished with synchronous converters vary considerably, but the following instructions apply generally to standard compound-wound

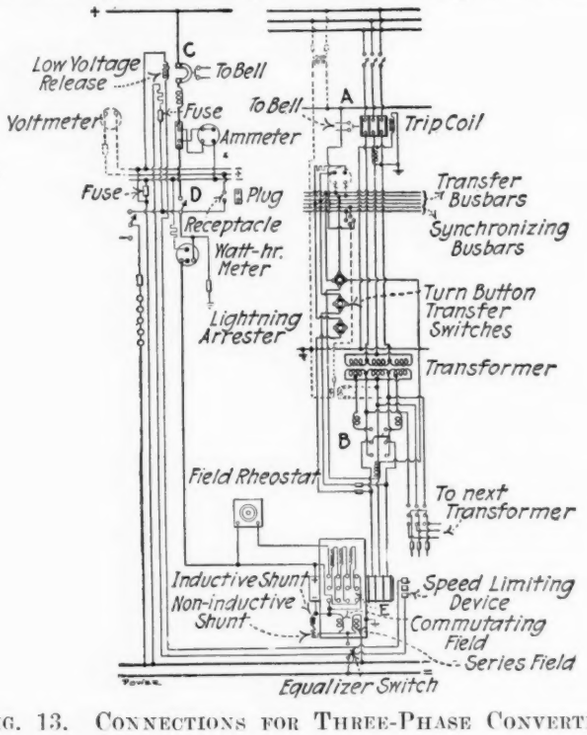


Fig. 13. Connections for Three-Phase Converter

converters used in railway service. The diagrams, Figs. 13 and 14, represent, respectively, the switching arrangements for three-phase and six-phase converters. Referring to these and, assuming that all the switches are open before starting and that the plug is inserted in the potential receptacle on the direct-current switchboard panel, thus connecting the machine to the voltmeter:

First: Close the main high-tension switch *A*.

Second: Close the starting switch *B* upward.

(For six-phase machines with tandem switches both switches *B* and *B'* should be closed upward, Fig. 14.)

The machine will then run up to speed and lock in step, which will be indicated by a cessation of the beats of the direct-current voltmeter.

Third: Close the equalizer switch *G*.

Fourth: Close the field break-up and reversing switch *E* into the top position.

Fifth: For three-phase machines throw the starting switch *B* quickly from the top to the bottom contacts, Fig. 13.

With six-phase machines, Fig. 14, throw the starting switch *B'* quickly from the top to the bottom contacts and then switch *B* to the bottom contacts. Finally open switch *B'*.

Sixth: Adjust the direct-current voltage to approximately that of the busbars.

Seventh: Push up the low-voltage release of the circuit-breaker and close the circuit-breaker *C*.

Eighth: Close the main switch *D*.

Ninth: Adjust the division of load between the machines if more than one are in service by means of the field rheostats.

If other machines are on the line when a compound-wound converter is started, the correct polarity may be insured by closing the equalizer switch *G* when the machine locks in step. By watching the swing of the direct-current voltmeter as the machine approaches synchronism, switch *G* may be closed just previous to the last two or three swings, thus insuring proper locking on the first trial, if there is current for the series field from other machines. If the machine should lock with the wrong polarity, as indicated by the direct-current voltmeter needle going down off the scale, the field switch *E* must be closed first into the down position, which will cause the voltmeter to return above zero, after which the switch *E* must be pulled out and closed into the top position. The reversal of polarity should be made while the machine is running on the first starting tap.

Shutting Down

To shut down a synchronous converter, open the circuit-breaker *C*, pull out and turn the circuit-closing auxiliary switch to stop the ringing of the alarm bell; open the main switch *D*; open the high-tension alternating-current oil switch *A*; allow the machine to run down in speed until the voltage falls off to about 100 before opening the field switch *E* or the starting switch *B*; then open the field switch *E*, equalizer switch *G* and starting switch *B*.

Precautions

The following precautions should be kept in mind when starting or shutting down synchronous converters:

Don't open the field switch *E* until the machine voltage has run down; otherwise the arc on opening the inductive field circuit may be blown by the armature blast

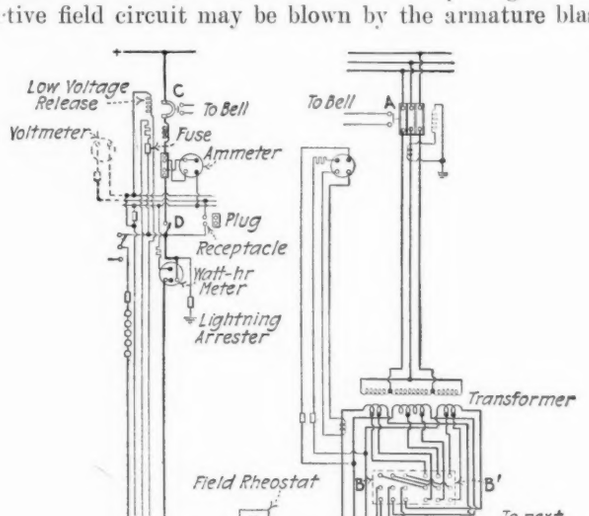


Fig. 14. Connections for Six-Phase Converter

from point to point, causing a short-circuit, or the strain may injure the insulation of the field winding.

Don't open the starting switches until the machine voltage has run down to zero. This leaves the transformers without a heavy residual magnetism, which tends to cause an extra rush of current when they are subsequently thrown into circuit.

Don't open the oil switch with the converter on the starting tap and the field closed; otherwise the converter

may build up to full voltage, tending to run up the transformers to considerably above normal voltage.

Don't parallel the machines on the direct-current side without closing the equalizer switches.

Don't start the converters with the field switch *E* closed either in up or down position, or with the series-shunt switch closed.

Don't close the alternating-current starting switch slowly into the top contacts, as the rush of current may pit the tips of the clips and thus prevent the blades from going in.

Don't close any switch slowly.

Don't close the circuit-breaker with the main switch *D* closed.

Don't close the circuit-breaker after a heavy short, without plugging in the voltmeter to make sure that the polarity is not reversed.

The diagram in Fig. 15 represents the field connections of a regulating-pole converter. In the main field circuit is the usual four-pole, double-throw, field break-up and reversing switch and rheostat. The regulating field windings on the smaller poles, and compensating field windings on the larger or main poles, are connected in multiple across the double-dial rheostat. This rheostat when turned from one extreme to the other will gradually change the excitations of the fields from a maximum in one direction to zero and then a maximum in the other direction. The compensating field winding also has a rheostat in series so that the proper relative strength between the regulating and compensating fields is adjustable to give the closest approximation to unity power factor at an average load throughout the voltage range obtainable by changing the excitation of the regulating field with the double-dial rheostat. (When the compensating field winding is not provided the power factor is kept at unity by the main field rheostat.) The compensating field rheostat can be best adjusted after the machine is installed for permanent operation.

In starting from the alternating-current side the field circuits are opened by the break-up switches. When synchronism has been reached on the first starting tap, proper polarity is obtained with the main field reversing switch, as previously described for the other converters. When the machine has been thrown to the full voltage of the transformer, the regulating and compensating field break-up switches are closed and the direct-current voltage is adjusted with the double-dial rheostat to the proper value for connecting to the direct-current busbars.

When starting from the direct-current side, the main field is excited to full strength the same as for the usual type of synchronous converters, and when running at approximate synchronism, the compensating and regulating field circuits are closed and adjusted to give the same voltage across the collector rings as that across the transformers. The speed is then adjusted to synchronism and proper phase relation by the main field rheostat before closing the main switches connecting to the transformer.

The regulating and compensating field windings on any pole are connected to excite in opposite directions so the resultant combined excitation of the whole pole, when the voltage is changed by the regulating field, will remain the same and will thus not affect the power factor appreciably. The compensating field when properly adjusted with the rheostat in its circuit will also make it easier to hold the speed constant when adjusting the alternating voltage for synchronizing when starting from the direct-current end.

Commutating-Pole Converters

The usual procedure, as described, for standard converters applies to those of the commutating-pole type, but in addition the brushes should be raised before starting and lowered after the machine is synchronized at full

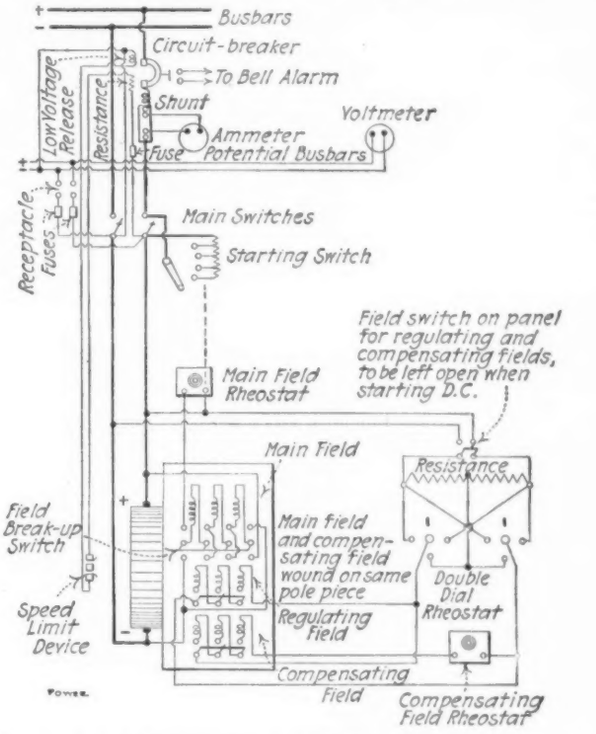


Fig. 15. Connections on Direct-Current Side of Regulating-Pole Converter

voltage—that is, the brushes should be lowered after the fifth operation.

Operation

It is important that two or more converters operated in parallel should divide their loads in proportion to their ratings. The division will be governed by the direct-current voltages, and these can be regulated by changing the applied alternating voltage, by one of the methods previously described. It is evidently necessary that all of the machines operating in parallel should have the same voltage regulation from no load to full load, and if a battery is also operated in parallel the voltage drop should be sufficiently large to cause the battery to take the excessive loads. If no battery is used, it will be more economical to have the machines designed for a smaller voltage drop.

Synchronous converters should always be operated at the voltage for which they are designed. However, it appears to be a common weakness among operators to run converters 5 to 10 per cent. above normal voltage on the direct-current side. This is done, of course, by increasing the shunt-field excitation to such an extent that the shunt field alone draws a leading current at no load, over and above which the series field adds additional leading current as the loads come on. The result of such operation is to practically double the average heating in the armature conductors at full load above that of unity power factor, on which the converter guarantees are based. More than this, such an operation increases the

heating of certain bars near the collector-ring taps to three or four times the normal value, in addition to the heat resulting from increased core loss in the armature due to overvoltage. The result is to practically cut down the capacity of the converter some 30 to 50 per cent.

In most cases, the average load is so low that no trouble is had, but as systems grow and load factors improve, the difficulty is likely to appear. The proper cure for this evil is to utilize proper taps in the transformers, so as to impress an alternating voltage sufficiently high, and to compel the operators to adjust the direct-current voltage for a sufficiently low value as to cause the converter to draw a considerable lagging current at no load, as previously explained.

Economical Selection of Belts and Pulleys

By W. F. Schaphorst

SYNOPSIS—Data pertaining to the selection of pulleys and belts which will give the best results with the least initial cost. Tables and curves are employed to assist the reader in making a determination of pulley and belt sizes.

In a prominent factory in the city of New York there is an engine that runs 75 r.p.m., transmitting 100 hp. from a 5-ft. pulley to a 4-ft. pulley. The distance between centers is 25 ft. Because of the slow engine speed and the relatively small driving pulley the belt has caused considerable trouble by slipping. Its velocity is less than 1200 ft. per min., but a velocity of 3000 ft. per min. would not be too high.

A 10-ft. driving pulley and an 8-ft. driven pulley would give the same final speed, and there would be less tendency of the belt slipping, because of the greater belt contact. The cost of the larger pulleys plus the cost of the correspondingly smaller belt required would be about $270 less.

Large pulleys should always be used, wherever possible, and especially if they can be proved most economical by the method cited.

In the factory mentioned a 40-in. belt is used. By doubling the diameters of the pulleys the belt speed is doubled and its transmission capacity is increased twofold. A belt only one-half as wide, or 20 in., would, therefore, suffice and its cost would be but one-half as great. The cost of the pulleys would be greater than in the present plant, but that increased cost would be more than counterbalanced by the decreased cost of the belt; $270 could be saved, and the transmission defects would be eliminated.

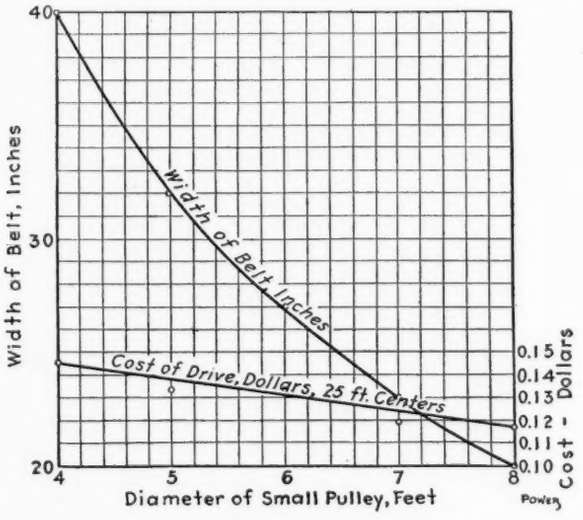

Width of Belt, Inches
Cost of Drive, Dollars, 25 ft. Centers
Width of Belt, Inches
Cost - Dollars
Diameter of Small Pulley, Feet
POWER

Fig. 1. Developing 100 Hp., Speed of Driving Pulley 75 R.P.M.

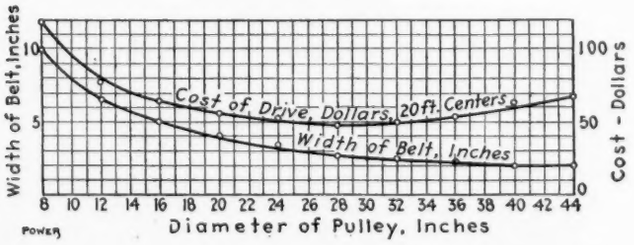


Fig. 2. Ten Hp., Speed of Driving and Driven Pulleys 400 R.P.M.

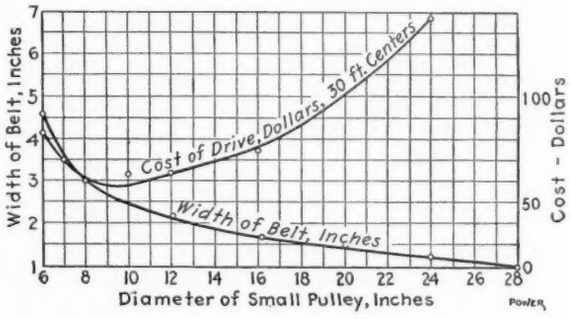

Width of Belt, Inches
Cost of Drive, Dollars, 30 ft. Centers
Width of Belt, Inches
Cost - Dollars
Diameter of Small Pulley, Inches
POWER

Fig. 3. Ten Hp., Large Pulley 300 R.P.M., Small Pulley 1200 R.P.M.

TABLE I.

Diam. Small Pulley, In.	Diam. Large Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Small Pulley	Cost of Large Pulley	Total Cost
48	60	40	64	$1023	$179	$253	$1455
60	76	32	67.7	867	187	288	1342
72	90	27	71.2	769	239	346	1354
84	106	23	74.7	687	211	299	1197
96	120	20	78.25	627	234	324	1185

In belt computations the rules that are most widely used are as follows:

Rule 1. A single-ply belt 1 in. wide, running 800 ft. per min. will transmit 1 hp.

Rule 2. A double-ply belt 1 in. wide, running 500 ft. per min. will transmit 1 hp.

To convert rule No. 1 into a formula applicable to most ordinary conditions, let

W_1 = Width of single-ply belt in inches;
W_2 = Width of double-thickness belt in inches;
H = Horsepower to be transmitted;
D = Diameter of driving pulley in feet;

N = Revolutions per minute of driving pulley;

πDN = Speed of belt in feet per minute;

$\frac{\pi DN}{800}$ = Horsepower a single thickness belt 1 in. wide will transmit.

Therefore,

$$W_1 = H \div \frac{\pi D N}{800} = \frac{800\,H}{\pi D N} = \frac{254\,H}{DN} \qquad (I)$$

By the same process rule No. 2 becomes

$$W_2 = \frac{159\,H}{DN} \qquad (II)$$

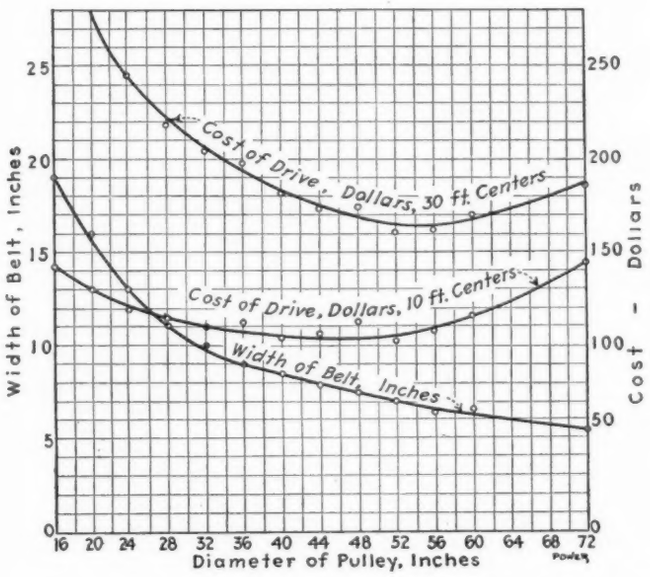


FIG. 4. TWENTY HP., SPEED OF DRIVING AND DRIVEN PULLEYS 200 R.P.M.

Adhering to the speed conditions laid down by the factory mentioned, a small pulley 5 ft. in diameter and a 6.25-ft. driving pulley would effect practically the same final speed. Applying formula (II) it is found that a 32-in. belt would be needed. Next, 6-ft. and 7.5-ft. pulleys with a 27-in. belt could be used.

TABLE II.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
8	10	42	$109	$10	$119
12	6½	43	67	12	79
16	5	44½	53	12	65
20	4	45½	43	13	56
24	3½	46½	36	15	51
28	2½	47½	31	18	49
32	2½	48½	29	21	50
36	2½	49½	27	24	51
40	2	50½	24	37	61
44	2	51½	25	42	67

TABLE III.

Diam. Small Pulley, In.	Diam. Large Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Small Pulley	Cost of Large Pulley	Total Cost
6	24	4½	64	69	3	9	81
7	28	3½	64½	58	3	9	70
8	32	3	65½	47	3	11	61
10	40	2½	66½	44	3	18	65
12	48	2½	67½	37	4	24	65
16	64	1½	70½	30	5	39	74
20	80	1½	73	26	6		
24	96	1½	75	23	8	109	140
28	112	1	78½	19	9	....	..

It is most convenient to tabulate these figures as in Table I with the length of the belt, the cost of the belt, and the costs of the pulleys. The total costs are then readily determined and compared. Plotting the total costs and belt widths, as in Fig. 1, the decreases in both are plainly shown.

The costs of pulleys and belting used in all of these tables are taken from the catalog of a manufacturer of transmission machinery and may be considered reliable for the problems solved here. Although, in this factory problem, the constant decrease in cost with increase in pulley diameters indicates that even larger pulleys might be still more economical, the curve could not be continued in this case because the limiting diameter of standard iron pulleys made by the manufacturers is 10 ft. Special pulleys would undoubtedly cost too much to be considered.

Table II and curves in Fig. 2 show that where 10 hp. is to be transmitted from a shaft making 400 r.p.m. to a second shaft 20 ft. away making 400 r.p.m. also, 28-in. pulleys and a 2¾-in. single belt would be most economical. The cost curve in this case being almost flat from the 20-in. pulley size to the 36-in. pulley size and

TABLE IV.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
16	19	64½	$293	$31	$324
20	16	65½	250	33	283
24	13	66½	206	37	243
28	11	67½	177	41	218
32	10	68½	164	41	205
36	9	69½	150	48	198
40	8	70½	135	46	181
44	7	71½	120	53	173
48	6½	72½	113	60	173
52	6	73½	106	54	160
56	5½	74½	99	62	161
60	5½	75½	100	70	170
72	4½	78½	85	100	185

the designer is allowed a wide range of choice, but it should be remembered that large pulleys generally give least trouble from slipping. The belt speed of 3000 ft. per min. with 28-in. pulleys is not excessive and may be allowed without question. Formula I was used in computing the belt widths in this and the other curves and tables.

Fig. 3 shows the least expensive combination where 10 hp. is to be delivered from a pulley making 300 r.p.m. to a smaller pulley making 1200 r.p.m. Distance center to center, is 30 ft. A small pulley 9 in. in diameter, a 36-in. driving pulley, and a 2¾-in. belt will do very well. Table III gives the computed results from which these curves were plotted.

Fig. 4 shows that the best sizes are not always dependent upon the distance between shaft centers. The upper cost curve shows that where driving and driven pulleys are the same size, where the speed is 200 r.p.m., where

TABLE V.

Diam. Pulley, In.	Width of Belt, In.	Length of Belt, Ft.	Cost of Belt	Cost of Pulleys	Total Cost
16	19	24½	110	31	141
20	16	25½	97	33	130
24	13	26½	82	37	119
28	11	27½	72	41	113
32	10	28½	68	41	109
36	9	29½	63	48	111
40	8	30½	58	46	104
44	7	31½	53	53	106
48	6½	32½	51	60	111
52	6	33½	48	54	102
56	5½	34½	46	62	108
60	5½	35½	47	70	117
72	4½	38½	42	100	142

20 hp. is to be transmitted and where the distance between centers is 30 ft., 52-in. pulleys and a 6-in. belt would be most economical. The lower cost curve is based upon the same conditions with the exception that the distance between centers is shortened to 10 ft. Although this shortens the belt considerably the plotted point on the curve nevertheless indicates that 52-in. pulleys and a 6-in. belt are again most desirable as regards first cost. The upper curve is plotted from Table IV and the lower curve is plotted from Table V.

It is, therefore, evident that the determination of pulley sizes need not be guesswork. After plotting curves similar to these the designer can exercise his judgment (which is needed in almost every design problem) to the best advantage. This method is simple, requires little time, and is sure.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—Hunter shows me something about pipe lines as found at the average colliery, the method of supporting them and the value of suitable pipe covering. Ways of extending a pipe line above a railroad track are illustrated and described.

A study of pipe lines extending from the boiler houses to the hoisting engines, pumps, breakers and fan engines interested me. On several occasions Hunter and I went to various collieries just to note the method of pipe-line extensions and the condition in which they were kept.

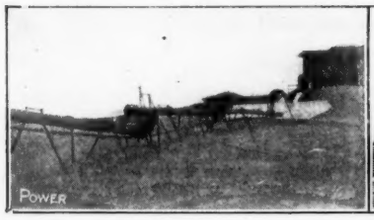


Fig. 1. Pipe Line in Service Twenty Years

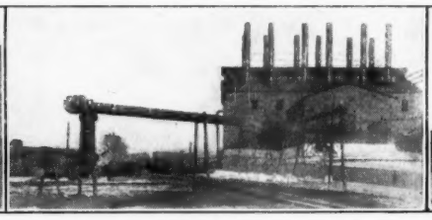


Fig. 2. Pipe Line and Expansion Joint

Fig. 3. S-Bends for Taking Care of Expansion and Contraction

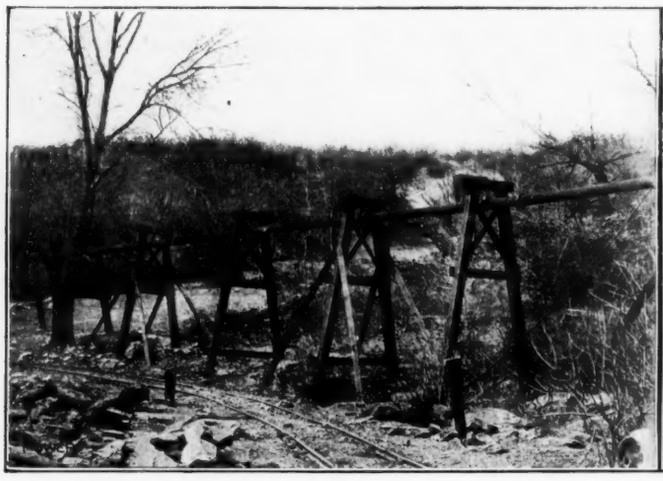


Fig. 4. A-Frame Pipe-Line Supports

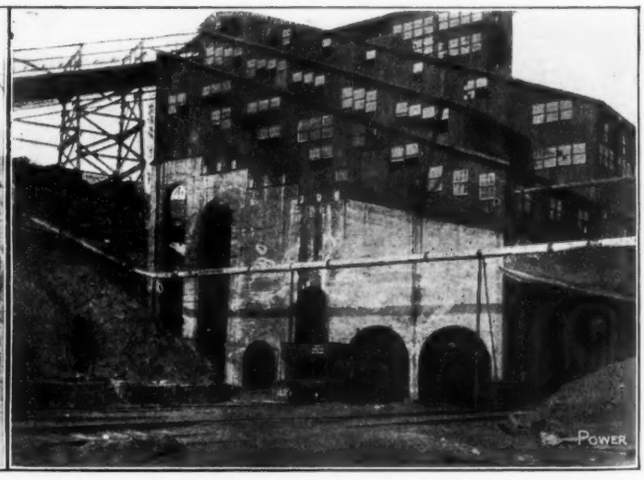


Fig. 5. Another Method of Supporting a Pipe Line

One pipe line, Fig. 1, was of exceptional interest, it having been in service something like 25 years, I think the superintendent told us. Although it shows irregularities, due to the settling of the surface when the old mine workings caved in, the joints are free from leaks. At the time the settling occurred only a few of the joints required attention. A first-class job must have been made when the pipe line was first installed.

A common expansion joint is shown in the foreground, consisting merely of four elbows and three nipples, making, when screwed together, an offset joint. This construction gives the pipe line on both sides of the joint an opportunity for free expansion as the temperature of the steam line changes. Hunter volunteered the information that we would find many such arrangements, and we did.

In Fig. 2 is a similar expansion joint, with the exception that a long nipple is used in the near vertical pipe. The longitudinal expansion is taken up at both top and bottom nipple joints, and the movement of both is but half what would take place in a single joint if the upper pipe dropped to a double ell and nipple. As these lines frequently run 8 and 10 in. in diameter in long lengths and carry a steam pressure around 150 lb., the expansion between a cold and a hot state is considerable. The pipe line illustrated is the main steam supply from the boiler house to the points of utilization.

Various methods are employed to suspend these lines. A common practice is to use metal or wooden A-frames having a tie piece at the top through which a U-bent piece, holding the pipe, is placed, the pipe being adjusted and held in position by nuts on the two ends of the yoke piece. This is illustrated in Figs. 1 and 3.

"There seems to be a difference of opinion regarding the proper height at which pipe lines should be suspended from the ground," said Hunter. "Some maintain that when the pipe lines are carried low (as shown in Fig.

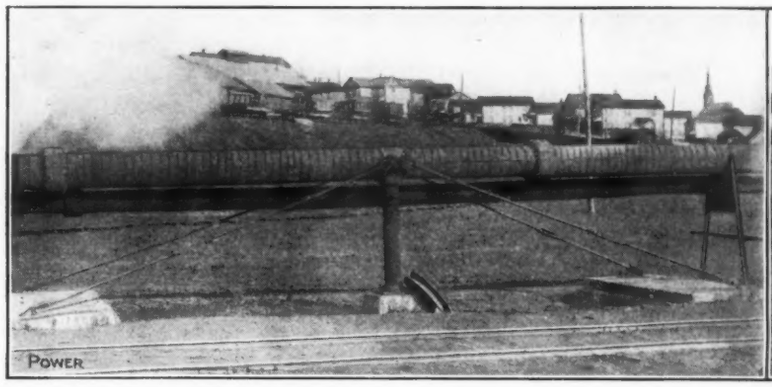


FIG. 6. A NEAT JOB OF PIPE COVERING AND ANCHOR STANCHION

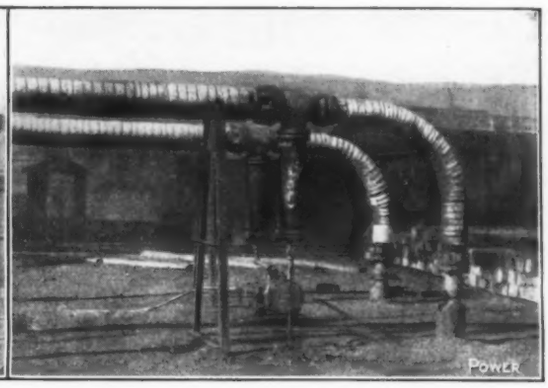


FIG. 7. SEPARATOR ON PIPE LINE LEADING TO MINE

1) that they are subjected to less condensation losses than when put up high, (indicated by Fig. 3), as the latter is more exposed to cold air currents. One advantage of the latter construction, however, is ample room for teams, etc., to pass under the pipe between the supports."

Another means of suspending pipe lines was noted, as illustrated in Fig. 4. This consists of a wooden A-frame with an eye-bolt passing through the top cross piece and held in place by a nut. A two-piece clamp is fitted around the pipe and bolted at the top and bottom, the upper bolt passing through the eye-bolt.

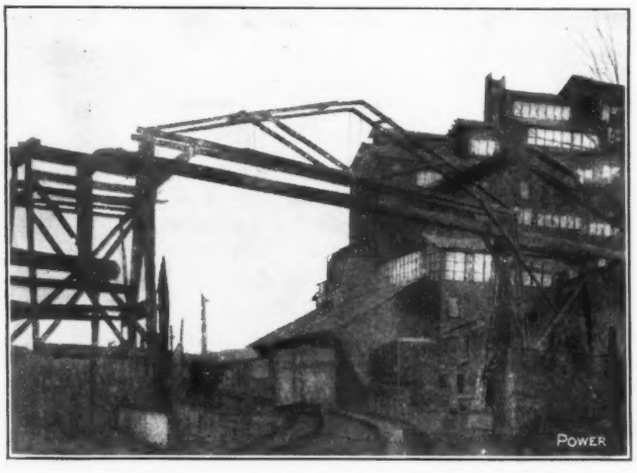


FIG. 8. PIPE-LINE SUPPORT OVER TRACKS

Still another way, shown in Fig. 5, consists of a metal upright piece having a forked upper end in which the steam pipe rests. Each supporting column may be secured by one or two diagonal braces from the top to an anchor buried in the ground. With but few exceptions, the steam pipes are covered with some kind of pipe insulation. In many instances, it was in a dilapidated condition, which must have allowed a large amount of condensation.

"The importance of proper covering for steam pipes and all apparatus about a steam plant where used cannot be too much emphasized," said Hunter. "Even with the best insulation, there will be some loss by condensation. The loss of heat from a bare steam pipe is taken by some authorities as approximately 3 B.t.u. per square foot per hour per degree of difference in temperature. For instance, taking a 10-in. pipe, 200 ft. long, carrying a steam pressure of 150 lb., 24 hr. per day, the approximate loss per year would be 3,528,000,000 B.t.u., or about 122 tons of coal. Just how much this loss will be reduced depends upon the value of the pipe covering."

A good example of pipe covering is shown in Fig. 6. On many lines we found that the flanges are left uncovered, probably to facilitate repacking the joint, but this omission permits of unnecessary condensation.

The illustration also shows a method of anchoring a pipe line. The anchor is a round metal upright stand, fitted at the bottom with a flange coupling, secured to a concrete base. A collar is fitted to the top of the stand and clamps the pipe. On each side of the clamp is a projection to which turnbuckles and rods are secured as shown. These rods are anchored in concrete and when the turnbuckles are tightened the upright stand is braced from both sides.

Some kind of a separator is generally used on long pipe lines. In Fig. 7 is shown the pipe for supplying underground apparatus, which runs from the boiler house and drops to the workings below through bore holes. Between the horizontal pipe and the bent section of each line, a separator is placed to remove the water of condensation before it reaches the vertical pipes. The separators on the two pipes shown are connected to a trap which takes care of the water. The pipes are insulated and wound with cloth.

It frequently happens that a pipe line must pass over a railroad track; passing the pipe under the rails forms a pocket in which water would collect. This can be overcome by building a framework above the tracks to support the line, as in Fig. 8. A more easily constructed pipe support can be made by placing an old rail on each side of the track, in a cement foundation, and fitting a

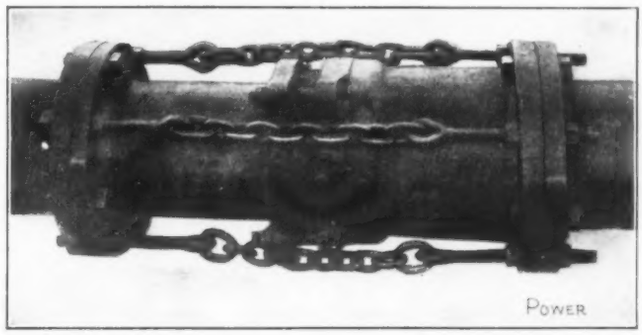


FIG. 9. EXPANSION JOINT ON AIR LINE

grooved pulley at the upper end of each rail. A wire rope or a chain is secured to an anchor outside of the rails and is passed over the two pulleys. A saddle is placed midway between the rails which support the pipe line at this point and is attached to the rope or chain, one of which should be made with a turnbuckle. As the turnbuckle is tightened, the tendency is to lift the pipe saddle. A threaded through rod from one rail to the other, with a nut on both sides of each rail, prevents the rails from bending in at the top. If the line is too heavy for two rails to support, a duplicate rail on each side of the track can be used with the grooved pulley attached to a cross piece. This arrangement would doubtless support any weight pipe line used about a mine.

In one instance, a long air pipe line was provided with an expansion joint which gave trouble by pulling out when the pipe contracted. To prevent this, four chains of suitable length were linked to two eye-bolts, the ends of which were put through the flange bolt holes, as in Fig. 9. A nut on each side of the flanges served the purpose of the regular flange bolts, and the chain prevented the joint from pulling out.

There were doubtless many other arrangements of pipe lines which we did not see, but even so, darkness found us plodding around culm piles and past somber mine shafts as we made our way back to the hotel and supper.

Working Up a Boiler Test--II

By F. R. Low

SYNOPSIS—An efficiency test is worked up item by item. The reduction to a dry coal and combustible basis is explained. How to find the evaporation per pound of coal as fired, per pound of dry coal, or of combustible under actual conditions or from and at 212. Different boiler efficiencies, boiler horsepower, and the cost per 1000 lb. of steam.

Suppose a boiler has been tested for efficiency; to see how well it is doing rather than how much it will do. This involves the determination of the amount of fuel used as well as the amount of water evaporated, and, if anything more than an approximation is wanted, the quality of both the fuel and the steam.

The accompanying table is the short form of test report recommended by the Committee on Boiler Tests of the American Society of Mechanical Engineers. Let us take it item by item and work out the values which are computed or deduced from those which are given.

Items 1 to 13 are the observed quantities and require no explanation.

Item 14 is the weight of coal fired, including moisture and the equivalent in coal of anything else that was put into the furnace, but not including unburned coal taken out of the furnace when cleaning or at the end of the test. One pound of wood may be taken to be equal to 0.4 lb. of coal.

Item 15 is obtained by weighing a sample of the coal before and after drying.

Item 16 is the weight of coal as fired less the moisture which it carried.

Then $1 - 0.0382 = 0.9618$

of it was dry coal, and

$$\underset{\text{Item 14}}{17{,}724} \times \underset{\text{Item 15}}{0.9618} = \underset{\text{Item 16}}{13{,}199.7432}\ lb.$$

Item 17 is the weight of stuff which went from the furnace into the ashpit during the test. It will be the ash and unburnable part of the coal plus whatever unburned coal gets through with it. It should, of course, be weighed dry.

Item 18 is the ratio of the ashpit refuse to the dry coal, the weight of stuff taken from the ashpit divided by the weight of coal (corrected for moisture) weighed to the furnace during the same time. It is expressed in per cent. and should not be confused with the percentage of ash in the coal by analysis, as it may contain a considerable proportion of unburned coal itself. In our case the weight of dry coal fired was 13,199.74 and that of the ashpit refuse 1238 lb. The ash and refuse are, therefore,

$$\frac{item\ 17 \times 100}{item\ 16} = \frac{1238 \times 100}{13{,}199.74} = 9.38\ per\ cent.$$

Item 19, the weight of water fed to the boiler during the test must be corrected for any difference in level at the beginning and end of the test and, if there is a very great difference in the pressure, for that also. It should truly represent the weight of water which has been put into the boiler and disappeared during the test; the amount weighed in plus or minus the amount required to make the water contents of the same weight that they were at the commencement. It should also be corrected as explained in the last article (page 371, POWER, Mar. 17) for any leakage or blowing down, which has occurred, while the test was in progress. In our case the weight is given as 111,654 lb.

Item 20. The steam made by the boiler may be moist or superheated. This item is the equivalent, in dry-saturated steam of the average pressure, of the steam as actually made. In our case the steam is moist; only 97.3 per cent. or 0.973 of the water has been actually evaporated, the rest being carried along by the steam as entrained moisture. The water actually evaporated (item 20) is, therefore,

$$\frac{item\ 19 \times item\ 13}{100} = \frac{111{,}654 \times 97.3}{100} = 108{,}639.34$$

If the steam were superheated the equivalent amount of dry-saturated steam of the same pressure could be found by dividing the difference between the total heat per pound (the **h** of the Marks-Davis superheated steam tables) and the heat of the liquid (the *h* of the tables) by the difference between the total heat of dry-saturated steam of the given pressure (the *H* of the tables) and *h*: and multiplying the pounds of water weighed in (item 19) by the quotient. The total heat **h** of steam of 127 lb. gage pressure, say, 142 absolute, superheated 100 deg. is 1248.1 B.t.u., that of dry-saturated steam of the same pressure 1192.5. The heat of the liquid at the given feed-water temperature 196 deg. (item 10) is, from the steam table, 163.92 B.t.u. To make a pound of steam under these conditions would take

Results of Boiler Test A. S. M. E. Short Form Code of 1912

1	Test of.....boiler, located at..... to determine	conducted by.....	
2	Kind of furnace.....		
3	Grate surface.....		62.50 sq.ft.
4	Water-heating surface.....		3,500 sq.ft.
5	Superheating surface.....		
6	Date.....		
7	Duration.....		12.50 hr.
8	Kind and size of coal.....		
	AVERAGE PRESSURES, TEMPERATURES, ETC.		
9	Steam pressure by gage.....		127 lb.
10	Temperature of feed water entering boiler.....		196 deg. F.
11	Temperature of gases leaving boiler.....		
12	Force of draft between damper and boiler.....		
13	Quality of steam.....		97.3%
	TOTAL QUANTITIES		
14	Weight of coal as fired.....		13,724 lb.
15	Moisture in coal.....		3.82%
16	Weight of dry coal consumed.....	Item 14 × (1—item 15)	13,199.74 lb.
17	Weight of ash and refuse.....		1,238 lb.
18	Ash and refuse in dry coal.....	Item 17 ÷ item 16	9.38%
19	Weight of water fed to boiler.....		111,654 lb.
20	Weight of water evaporated.....	Item 19 × item 13 if moist; Item 19 × $\frac{h - h}{H - h}$ if superheated	108,639.34 lb.
21	Equivalent evaporation from and at 212°....	Item 20 × $\frac{H - h}{970.4}$	115,846.84 lb.
	HOURLY QUANTITIES AND RATES		
22	Dry coal consumed.....	Item 16 ÷ item 7	1,055.98 lb.
23	Dry coal per sq.ft. of grate.....	Item 22 ÷ item 3	16.9 lb.
24	Weight of water evaporated.....	Item 20 ÷ item 7	8,691.15 lb.
25	Equivalent evaporation from and at 212°....	Item 21 ÷ item 7	9,267.75 lb.
26	Equivalent evaporation from and at 212°..... per sq.ft. of water-heating surface.....	Item 25 ÷ item 4	2.65 lb.
	CAPACITY		
27	Evaporation per hr. from and at 212°.....	= item 25	9,267.75
28	Boiler horsepower developed.....	Item 27 ÷ 34.5	268.63 hp.
29	Rated capacity.....	Item 30 × 34.5	12,075 lb. per hr.
30	Rated capacity.....	Item 29 ÷ 34.5	350 hp.
31	Ratio of developed to rated capacity.....	Item 27 ÷item 29, or item 28 ÷item 30	76.75%
	ECONOMICAL RESULTS		
32	Water fed per lb. of coal fired.....	Item 19 ÷ item 14	8.14
33	Water evaporated per lb. of dry coal.....	Item 20 ÷ item 22	10.29
34	Equivalent evaporation from and at 212° per lb. of dry coal.....	Item 21 ÷ item 16	8.78
35	Equivalent evaporation from and at 212° per lb. of combustible.....	Item 21 ÷ Item 16 — item 17	9.68
	EFFICIENCY		
36	Calorific value of 1 lb. of dry coal.....		12,700 B.t.u.
37	Calorific value of 1 lb. of combustible.....	Item 36 ÷ % ash in coal	13,700
38	Efficiency of boiler furnace and grate.....	(Item 35 × 970.4 × 100) ÷ Item 37	68.57%
39	Efficiency of boiler and furnace.....	(Item 34 × 970.4 × 100) ÷ Item 36	67.09%
	COST OF EVAPORATION		
40	Cost of coal per ton delivered in boiler room.....		3.60 dollars
41	Cost of coal required to evaporate 1000 lb. of water from and at 212°.....	$\frac{1000 \times \text{Item 14} \times \text{Item 40} \times 100}{\text{Item 21} \times \text{No. of lb. in ton}}$	21.33 cents

(*superheated* **h** — *h*) 1248.1 — 163.92 = 1084.18 B.t.u.
(*dry-saturated H* — *h*) 1192.5 — 163.92 = 1028.58 B.t.u.
The heat absorbed by the boiler to make a pound of the superheated steam would, therefore, make

$$1084.18 \div 1028.58 = 1.054 \text{ } lb.$$

of the dry-saturated steam, and this multiplied by the water evaporated into superheated steam, which would be all that fed to the boiler (item 19) would give the equivalent amount of water evaporated into dry-saturated steam of the same temperature (item 20).

Item 21. For comparison it is usual to reduce the actual performance of a boiler to the equivalent evaporation from and at 212 deg. This is done by dividing the amount of heat which it takes to make a pound of steam under the actual conditions, $H - h$, by 970.4, the amount of heat which is required to evaporate a pound of water at 212 deg. into dry-saturated steam, of the same temperature. This quantity

$$\frac{H - h}{970.4}$$

is called the "factor of evaporation" and gives the equivalent evaporation from and at 212 deg. of 1 lb. under the conditions for which H and h are taken. Multiplying the quantity actually evaporated (item 20) by this factor gives the equivalent amount evaporated from and at 212.

For our case the gage pressure is 127 lb. (item 9) or

$$127 + 14.7 = 141.7 \text{ } lb. \text{ } absolute$$

This corresponds to temperature 354 in the Marks-Davis tables where the value of H is found to be 1192.4. The value of h at the given feed-water temperature 196 deg. (item 10) is 163.92; then

$$\frac{H - h}{970.4} = \frac{1192.4 - 163.92}{970.4} = 1.0599$$

This is the factor of evaporation and multiplying the evaporation under the actual conditions by it we have

$$item\ 20 \times \frac{H - h}{970.4} = 108{,}639.34 \times 1.0599 = 115{,}846.84 \text{ } lb.$$

The same formula will apply for superheated steam if H is taken as the total heat **h** of such steam and item 19 may be multiplied directly by the factor of evaporation so found. A table of factors of evaporation for dry-saturated steam of different pressures with different temperatures of feed will be found on pages 369 and 370 of the Mar. 17 issue.

Items 22, 24 and 25 are simply the *total* quantities of dry coal fired (item 16), steam actually made (item 20), and steam which would have been made from and at 212 deg. (item 21) reduced to quantities *per hour* by dividing by the duration of the test (item 7).

$$item\ 22 = item\ 16 \div item\ 7 = 13{,}199.74 \div 12.5 = 1055.98$$

$$item\ 24 = item\ 20 \div item\ 7 = 108{,}639.34 \div 12.5 = 8691.15$$

$$item\ 25 = item\ 21 \div item\ 7 = 115{,}846.84 \div 12.5 = 9267.75$$

Item 23 is the number of pounds of dry coal burned per hour per square foot of grate, and is found by dividing the whole number of pounds of dry coal per hour (item 22) by the number of square feet of grate surface (item 3). In our case

$$\frac{item\ 22}{item\ 3} = \frac{1055.98}{62.5} = 16.9 \text{ } lb.$$

Item 26 is the number of pounds of steam, reduced to the equivalent from and at 212 deg., made per hour by each square foot of water-heating surface and is found by dividing the total evaporation per hour under those conditions (item 25) by the number of square feet of water-heating surface in the boiler (item 4)

$$\frac{item\ 25}{item\ 4} = \frac{9267.75}{3500} = 2.65 \text{ } lb.$$

Item 28 is an expression of the unscientific but persistent usage of expressing the performance of a boiler in horsepower. The calculation was fully explained in the previous article.

It is generally accepted that the evaporation of the equivalent of 34.5 lb. per hour from and at 212 deg. constitutes a horsepower so the capacity in horsepower may be found by dividing the equivalent evaporation per hour from and at 212 deg. (item 27) by 34.5.

$$\frac{item\ 27}{34.5} = \frac{9267.75}{34.5} = 268.63 \text{ } hp.$$

Items 29 and 30 are the builder's rating, which must be got from him. It is much more sensible to rate the boiler directly in pounds of steam which it will make per hour from and at 212 deg., as in item 29, and this practice is being followed more and more by engineer buyers. The horsepower rating is usually computed at 10 sq.ft. of water-heating surface per horsepower.

Item 31. If the boiler evaporates 9267.75 lb. of steam from and at 212 deg. per hour (item 27) and is rated as being able to evaporate 12,075 lb. (item 29 equivalent of 350 hp.) it develops

$$\frac{9267.75 \times 100}{12{,}075} = 76.75 \text{ } per\ cent.$$

of its rated capacity, or

If the boiler does 268.63 hp. and is rated at 350, it is doing

$$\frac{item\ 28 \times 100}{item\ 30} = \frac{268.63 \times 100}{350} = 76.75 \text{ } per\ cent.$$

of its rated capacity.

Item 32 gives the amount of water which disappeared per pound of coal fired, including the moisture in the steam and the coal.

$$\frac{item\ 19}{item\ 14} = \frac{111{,}654}{13{,}724} = 8.14 \text{ } lb.$$

Item 33 gives the number of pounds of water evaporated per pound of dry coal

$$\frac{item\ 20}{item\ 22} = \frac{108{,}639.34}{1055.98} = 10.29$$

Item 34 gives the equivalent evaporation from and at 212 deg. per pound of *dry* coal

$$\frac{item\ 21}{item\ 16} = \frac{115{,}846.84}{13{,}199.74} = 8.78$$

Item 35 is the same quantity again per pound of combustible burned, not per pound of combustible fired, for there will be some of the combustible in the ashpit refuse. The combustible burned is the difference between the weight of the coal fired and that of the ashpit refuse.

$$\frac{item\ 21}{item\ 16 - item\ 17} = \frac{115{,}846.84}{13{,}199.74 - 1238} = 9.68 \text{ } lb.$$

Item 36 is best determined by burning a sample of the coal in a coal calorimeter. The valve given here is 12,700 B.t.u. per lb.

Item 37 cannot be determined without knowing the percentage of ash or noncombustible matter in the coal which may be materially different from item 18 on account of the combustible in the ashpit refuse. Assume the percentage of true noncombustible in the coal to be 7.3 per cent. of the weight of the dry coal, then 1 — 0.073 = 0.927 of a pound of combustible would have 12,700 B.t.u., and one pound of combustible

$$\frac{12{,}700}{0.927} = 13{,}700 \; B.t.u.$$

Item 38. For every pound of combustible burned under it the boiler made the equivalent of 9.68 lb. of steam from and at 212 deg. (item 35). For each pound of steam it absorbed 970.4 B.t.u. For each pound of combustible furnished, therefore, the boiler absorbed 970.4 × 9.68 = 9393.472 B.t.u., which is

$$\frac{item\ 35 \times 970.4 \times 100}{item\ 37} = \frac{9.68 \times 970.4 \times 100}{13{,}700} = 68.57\%$$

Item 39. For each pound of dry coal which the boiler had supplied to it, it evaporated the equivalent of 8.78 lb. of water from and at 212 deg. (item 34). For each pound of coal furnished, therefore, the boiler absorbed 970.4 × 8.78 B.t.u., and as each pound of dry coal carried in 12,700 B.t.u., the whole outfit, boiler-grate furnace, etc., utilized.

$$\frac{item\ 34 \times 970.4 \times 100}{item\ 36} = \frac{8.78 \times 970.4 \times 100}{12{,}700} = 67.09\%$$

If more of the coal had gone through the grate or if the coal were less completely burned the result would be lower, so that this value includes the efficiency of the grate, while that of item 38, based upon the difference between the coal fired and the ashpit refuse does not.

Items 40 and 41. By dividing item 21 by item 14 we can find how many pounds of steam can be made from and at 212 deg. per pound of the coal as it comes to us. To make 1000 lb. would require $\frac{1000 \times item\ 14}{item\ 21}$. The cost per pound is item 40 divided by the number of pounds in a ton (2000 or 2240, according as the price is given per short or long ton) and multiplied by 100 to reduce to cents. Suppose our price to be $3.60 per short ton the cost of coal to evaporate 1000 lb. of water from and at 212 deg. will be

$$\frac{1000 \times item\ 14 \times item\ 40 \times 100}{item\ 21 \times 2000}$$

$$= \frac{1000 \times 13{,}724 \times 3.60 \times 100}{115{,}846.84 \times 2000} = 21.33c.$$

Feed Heating by Live Steam

By A. Braucher

SYNOPSIS—By citing a few simple experiments to show the rapidity with which boiling water takes up heat and the relative slowness with which cold water absorbs heat, especially when the circulation is impaired, the author argues for the introduction of feed water at boiling temperature into the steam space of the boiler.

The arguments for and against using live steam for heating feed water are well known. The theorist has failed to make good in his attempt to deny the gain claimed by practical engineers to result from such feed heating because it was in direct contradiction with his theory; he should have amended his theory to agree with the facts. It is the purpose of this article to submit a number of facts, some of which do not agree with what one would naturally suspect from the conditions; also, to deduce a satisfactory theory to explain the gain and saving due to feed heating with live steam.

Water at a temperature of 500 deg. when discharged into the atmosphere from its confining pressure will absorb its own heat so rapidly in evaporating a portion of it and expanding the vapor that a person may stand with impunity within a few feet of and in line with an inch discharge nozzle. The vapor itself as well as the straggling drops of water will feel cool instead of hot.

If the exhaust from an engine is discharged upward into a stack which is open at the top and bottom, much of the exhaust steam will be condensed, and the drops of water descending through the ascending column of mixed air and vapor will feel cool to the hand. This cooling is caused by the steam giving up to the air the heat required to expand the latter to the volume due to the increased temperature.

Gas or air under pressure at an ordinary temperature will absorb heat rapidly upon being allowed to escape into the atmosphere or even into a compartment which is under less pressure. This absorption of heat is sufficient to produce freezing of the contained moisture in the case of air at a temperature of 60 deg. and under a pressure of 60 lb. when exhausted into the atmosphere. The same effect is produced in the natural-gas regions, where the initial pressure of the wells is high and is reduced by means of a reducing valve. Also, where a small quantity of gas is allowed to pass through a valve for use as fuel, the pipe between the valve and the furnace becomes covered with frost. Steam escaping under pressure will absorb its own heat so rapidly that the hand may be held in the escaping vapor at a slight distance from the point of issue without discomfort.

Boiling water absorbs and stores up as latent all available heat of an intensity greater than the degree at which the boiling takes place, depending upon the pressure to which the liquid is subjected. A reduction of pressure will produce an enforced evaporation, and the heat necessary to accomplish it will be absorbed with avidity from the surrounding surfaces or from the body of the liquid itself, depending upon the relative temperature of the two and also of the liquid in contact with the heated surfaces. If that liquid is below the point of evaporation, due to the pressure, evaporation will not take place in contact with the heated plates and the enforced absorption of heat from the heated surfaces will not take place.

It is the evaporation of water and the resulting rapid absorption of heat that makes it efficient in extinguishing fire. If the water could not evaporate, and could only absorb the heat by an equivalent rise in temperature,

the water would become red hot in a short time and would be but little better in putting out a fire than so much shot (iron) thrown upon it.

Cold water is a poor conductor of heat, and is heated by convection when the point of application of the heat is below, as water may be boiled for hours by heating from above and remain practically unaffected below; also, ice will not melt to exceed 3 in. below the surface with two hours' boiling at the surface.

A particle of water in evaporating instantly absorbs enough heat to have raised its temperature from 32 to 1000 deg. F. had it continued to exist as water. It is evident that water at 32 deg. cannot possibly absorb instantaneously heat enough to raise its temperature a small number of degrees, even if the plate with which it is in contact were red hot, as witnessed by the spheroidal state of water.

A glass boiler with a flat metallic bottom for the heating surface was arranged so that water could be introduced into pans in the steam space or into the water space in the ordinary way. When cold water was fed into the water space the boiling ceased almost immediately, while it increased perceptibly when fed into the pans in the steam space. The boiler could be removed entirely from the source of heat and remain for some time after it had ceased to boil, when it would boil rapidly again upon feeding cold water into the pans in the steam space.

A boiler that has stood up under heavy service all day will sometimes "bag a sheet" after the engine has been stopped, the feed turned on and the fire banked. This is caused by the sudden change from conditions favorable to the rapid absorption of heat from the heating surfaces to the worst combination of conditions against such absorption. During the day the rapid consumption of steam causes a strong ebullition, keeping the water in circulation, preventing sediment or loose scales from settling on the heating surfaces, and the heat is rapidly absorbed in the evaporation. When the engine is stopped and the feed turned on, ebullition ceases, a layer of sediment settles down on the heating surfaces, causing a rapid accumulation of heat in the boiler plates.

The question now resolves into whether there should be boiling water in contact with the plates and tubes, or water below the boiling point. To have boiling water, live steam must be used to heat it; but it will absorb more heat from the heating surface by reason of its being at the boiling point. With cold water (any temperature below that due to the working pressure of the boiler) in contact with the plates and tubes, we will save the steam necessary to heat it to boiling, but will lose in heat being absorbed more slowly by the cooled water. In the first case, the heat is "pulled" into the water by reason of the enormous demand for heat sufficient to make the change from water to steam, while in the second case the heat is "pushed" into the water in opposition to its nonconducting property.

Other gains from feeding water at the boiling point are the increased circulation, the maintenance of a uniform temperature in all parts of the boiler, and the possibility of removing impurities from the circulating water, thus adding to the power and safety of the boiler and reducing the expense for fuel and repairs.

It is sometimes claimed that the balance or equality of temperature between the water and the steam within the boiler is maintained automatically, some of the water passing into the steam or some of the steam being condensed into the water to make up any excess or deficiency of heat in the one or the other. There is a wonderful capacity for making up any deficiency in the steam space by the evaporation of water, but not so in getting the heat back from the steam into the water. This is plainly shown in connection with the continued boiling of water in one compartment of an air-tight system, when removed from the source of heat, to replace the steam in another compartment in which the steam is being condensed by immersion in a bath of mixed ice and salt. The bulb containing the boiling water will lose its heat rapidly and will feel cold to the hand while the pipe connecting the two compartments is still quite hot, showing that the enforced boiling is at the expense of the heat in the water, cooling it rapidly, even to the extent of freezing it by boiling if the system is entirely freed of air so that the condensation of the vapor will reduce the pressure to a vacuum as the temperature is reduced.

The difficulty of getting the heat from the steam to the water when there is a deficiency of heat in the water is plainly shown by observation of conditions existing in a firebox boiler into which too much cold feed water has been introduced below the water line. Often the water drawn off through the blowoff valve is found to be cold while the steam gage indicates 80 to 100 lb., and the temperature would not become unbearable to the hand until a considerable portion of the surplus water had been withdrawn.

Venning Improved Sectional Water-Tube Boiler

Interest is being shown in a sectional water-tube boiler manufactured in Canada and designed by A. Venning, Preston, Ont.

In many respects, it resembles the ordinary type of water-tube boiler, but embodies several features designed to improve the circulation and steaming capacity, increase the area for mixing, combustion and travel of the gases, eliminate tube troubles and reduce the cost of maintenance and repairs. It is made of wrought steel to comply with the government regulations.

The circulating tubes between the steam drums and the tops of the rear headers are dispensed with, and, instead, one large circulating pipe, Fig. 1, is used to convey the water from each drum to the bottom of the header sections, thus directing a full supply of water to the lower rows of tubes where it is most needed. The pipe also keeps the tubes well supplied under all conditions and thus insures a constant, rapid and positive circulation.

The forged-steel headers and nipple connections are also larger than usual, so that the steam is provided with a ready means of escape as soon as it is generated. The effect of this mode of circulation will be readily appreciated when it is realized that at least 70 per cent. of the steam is generated in the lower rows of tubes; that with the water flowing in one direction, every tube is brought into action, there being no possibility of short-circuiting in some tubes, with sluggish or even reversed currents in others.

The headers are made of forged steel and so staggered that one tube overlaps the space beneath it. They are of larger section than usual and by having the tube spacing

increased with an easier curve of sinuation, provide a greater internal area of waterway and offer a minimum resistance to the flow of steam and water.

The handholes opposite the end of each tube are oval, Fig. 2, being cut out of the solid metal; the tube holes are drilled by the same machine, with no punching work whatever in the manufacture of the headers. The hand-

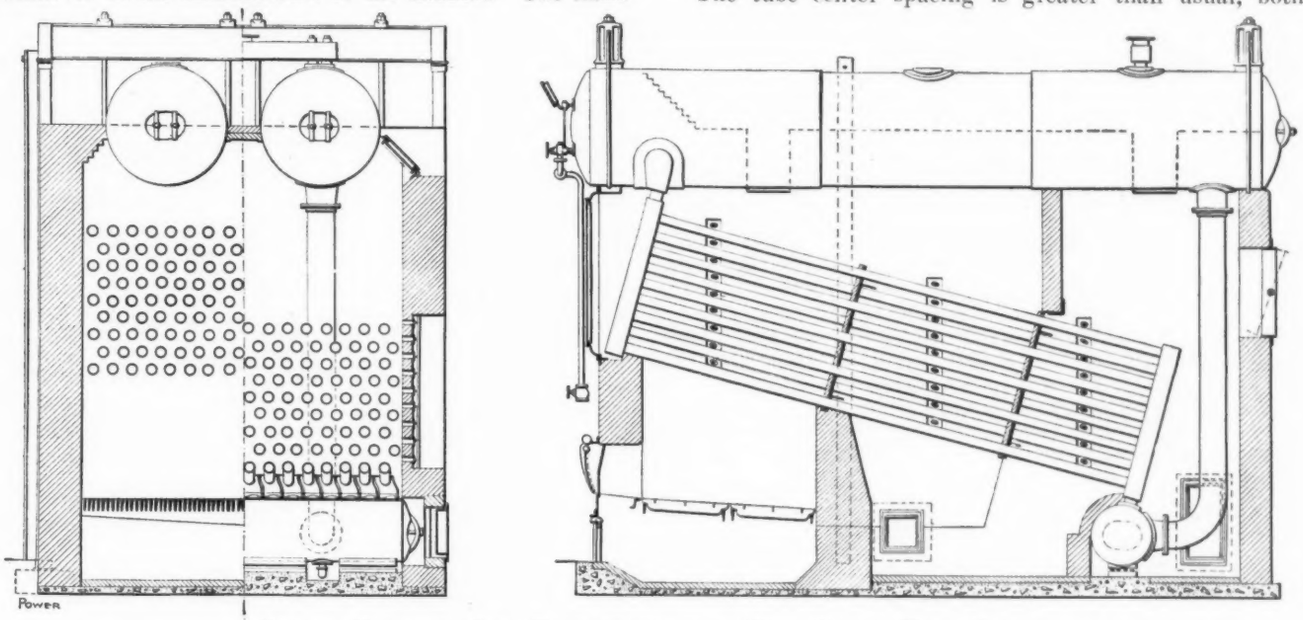


FIG. 1. END AND SIDE ELEVATIONS OF A NEW WATER-TUBE BOILER

The end elevation shows a half section through the furnace and rear pass. The side elevation shows the connections between the drums and the tubes and the rear bottom drum.

hole cover plates are placed on the interior with ample clearance between the plates and the header; the joint is made with a thin gasket, bearing on machined surfaces.

The steam and water drums are of large diameter and at the front end of each and riveted to it is a forged-steel cross box, made from a solid plate without weld or seam, the box being connected to the front headers by 5-in. nipples, giving a large discharging capacity.

At the rear of each drum and connected to a wrought-steel nozzle is a large circular lap-welded, steel, downtake pipe, which conveys the water to the bottom of the headers. Both are connected to a 24-in. cross drum at the lowest point of the boiler and in a position remote from the action of the fire and the hot gases. It is made of steel plate, riveted and reinforced at the nipples.

By using a large drum, the velocity of water passing through it is greatly decreased so that the solid material in the water has time to precipitate somewhat. As the points of entry are limited by the number of downtakes, the impurities settle at these points and are drawn off by the blowoff pipe placed beneath each opening. With this reduced velocity and a change in the direction of flow, there is less chance of impurities being swept directly into the generating tubes than if the water had to force its way to the bottom of the headers.

The drum is carried on roller plates, resting on a solid foundation, provision being made for the blowoff pipes to be placed at the bottom. Another feature is that, with double-drum boilers, these large downtakes act as equalizing pipes in maintaining a uniform water level in both drums.

The joints at the flanges of the downtakes suffer no injurious effects from the action of the gases, it is said, no trouble being experienced with the boilers already installed. The pipe, by having an elbow at the lower end, compensates the effects of expansion and of contraction. It is satisfactory in operation, and as the drums are suspended in the usual manner from rolled-steel beams and channels, no weight is brought to bear on this pipe.

The tube center spacing is greater than usual, both horizontally and vertically, giving more room for the mixing and the combustion of the gases, with a larger area in each pass for their travel, so that the baffles can

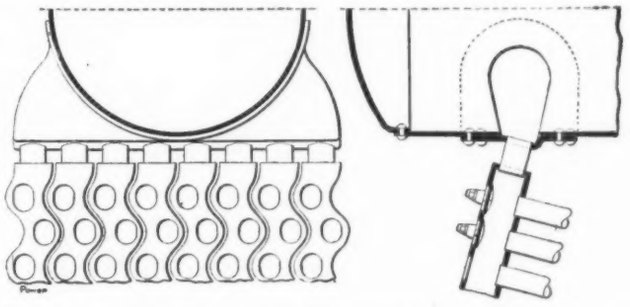


FIG. 2. ARRANGEMENT OF HEADER AND SPACING OF THE TUBES

be carried the full depth of the section, thus making the whole of the tubular heating surface effective.

The floor space occupied by this boiler is slightly greater than in many others, on account of the increased spacing of the tubes. As the quantity of water a boiler will evaporate is not directly dependent on the amount of its heating surface nor on the quantity of coal it will burn, but mainly upon its effective circulation, it will be seen that the question of space is offset by other material advantages in the boiler itself.

The boiler can be made with a number of 5-in. downtake pipes, expanded into a cross box at the rear of the drum, or curved and expanded into the side of the mud drum, thus dispensing with the special nozzles and more costly pipe, and at the same time providing a positive circulation throughout.

Superheaters can be attached in the usual way.

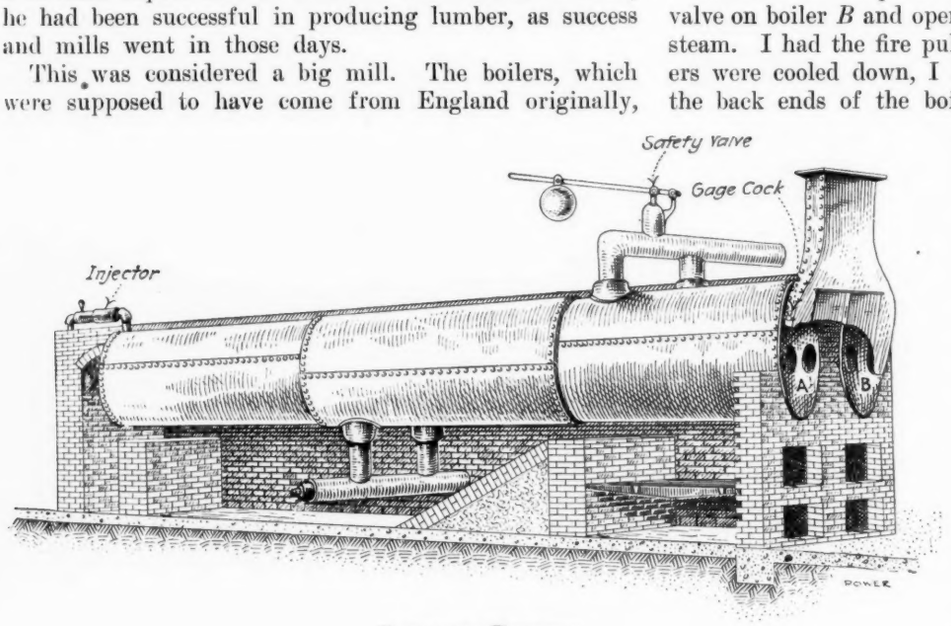
Some Steam Plants!

By George F. Willis

During some 40 years of all kinds of experience, I have seen steam plants run so closely to the ultimate end of things that cold chills ran up my back to be in them. I once walked out of a sawmill in Alabama, after having spent a few minutes there. In that time they were trying to make an injector work, with no water in sight in the boiler and steam blowing off at 130 lb. Before I had gone a half mile the boilers exploded.

Of all the experiences I ever had, the following was the extreme limit. Back in the eighties, my father sent me to a little town in Tennessee to run a sawmill. This mill had been operated by a man who was put down as a sawmill expert in that section. As a matter of fact, he had been successful in producing lumber, as success and mills went in those days.

This was considered a big mill. The boilers, which were supposed to have come from England originally,



Sawmill Boilers

had been taken out of a Mississippi River steamboat after many years' service. They were 40 in. in diameter by 30 ft. long, each had two 14-in. flues, and were connected together below by what was called a "standpipe," although I have no idea where the name originated. This device consisted of a U-shaped cast-iron pipe with about a 2½-in. opening. Each of the legs was connected to a boiler, and from the bottom of this pipe, in either direction, led a connection of the same size, running through the boiler walls. The water supply was supposed to be put in through the left-hand end of this connection, while the blowoff valve was on the other end. The blowoff valve and connection was in place all right, fortunately, as will be seen, but—as there was no feed pump—the other end was blanked!

The feed water was supplied to the boilers by an injector, which had been piped into the back end of the left-hand boiler. On this same boiler, on the front end, was one solitary gage-cock, the others having long since been broken off and the holes filled with iron plugs. The two boilers were connected above by a cast-iron pipe similar to the one described, having two openings, one for the steam line to the engine and the other for a safety valve.

With two boilers so connected and fed through one of them (call it *A*), if the other (*B*) got any water, it had to go down the leg from boiler *A* and up through the leg into *B*. There was nothing whatever to show the water level in boiler *B*, and only one gage-cock on *A*.

I asked the "engineer" how he knew where the water level was. He said if it "showed," he cut off the injector, and if it did not he started it. As there was no steam gage, I inquired how he told what the pressure was. He said if the engine "pulled" all right, he knew he had enough; if it did not, he fired up!

Although an inexperienced boy, I knew this would not do, so I got some gage-cocks, three for each boiler, and after a day's work drilling out the iron plugs and threading, I got them placed. Then I put on a pressure gage, but, as I remember it, I used the old opening on top of boiler *A* for this. Next I started to get up steam.

At about 30 lb. pressure I went around to the blowoff valve on boiler *B* and opened it. All I could get was blue steam. I had the fire pulled at once, and when the boilers were cooled down, I took out the manhole plates in the back ends of the boilers, and looked in. Boiler *B* had no water at all, and the U-pipe connection from boiler *A* was entirely stopped up by scale and rust. There was no opening to be seen.

I got this cleared out, and started the fires again. At about the same pressure as before, with a long stick, I raised the lever of the safety valve. This was a long-weighted lever with a cast-iron ball on it as large as a man's head. I lifted the lever and ball all right, but no steam blew out. I pulled the fires again, and investigated. Evidently some time the valve had leaked, and the "engineer" had poured 25 lb. of melted babbitt on top of the valve to stop the leak.

The engine, which was 14x24 in., had no governor and was controlled by what we then called a "sawyer's" valve, which was really a pivoted disk in the steam line. When the sawyer pulled this valve wide open, the engine did the best it could with the load.

He usually speeded the engine up to about what he thought it would stand, and plunged the saw into the cut. I am willing to gamble that the rim of the engine wheel had many times exceeded all safe limits, and that, theoretically, it should have burst long ago. I put on a fly-ball governor; the men did not think much of it.

The boilers were of the softest and most ductile iron. I remember well how this iron cut and looked. The boilers had been in use for years before doing duty in the sawmill, and the mill had been run years and years in different locations before I ever saw it. What pressures the boilers had been under is a wild guess. Just guessing will never come within a half mile of the truth!

All this is absolutely true and unexaggerated.

Coal Briquettes to the amount of 181,859 tons, valued at $1,007,327, were manufactured in 1913, according to Edward W. Parker, of the U. S. Geological Survey. Compared with 1912, there was a decrease of 17 per cent. in tonnage, but an increase of 5½ per cent. in value.

Editorials

Uncle Sam's Home-Made Current

On other pages of this issue are given the operating data of the Chicago Federal Building plant, and an estimate is made of the saving effected by the installation of generating units to supply current for power and lighting. The building had ample capacity in boilers which were installed to supply steam to elevator pumps, air compressors, miscellaneous machinery and to the heating system, as the supply of exhaust steam only fulfilled about one-half the demand for heat in the colder weather. It was a simple matter to install engine-driven generators which would reduce this steam to the proper pressure for heating and at the same time generate all the current that was needed for light and power.

The advantage of such an arrangement was apparent, and government officials selected to investigate, estimated an annual saving of at least ten thousand dollars over buying current. Notwithstanding, it required years of agitation to overcome powerful political influence brought to bear and a reduction in rates tendered by the central station. When the matter was brought to the attention of the present administration, the installation of an isolated plant was sanctioned, and the results obtained in the first month's operation vindicate the decision made at Washington.

The plant has exceeded expectations. Running under adverse conditions at the start, it has made a saving of seventeen hundred dollars for the month of March as compared with the same month of last year. Due to delay in installing a meter, no records are available on the actual steam consumption of the engines, but meters installed for the other departments showed that more steam was generated, excluding that taken by the generating units. The temperatures were nearly the same and the cost of coal varied only four cents per ton. Under these conditions the difference in total operating expense was the foregoing figure. With the operating conditions improving, as they will, the saving should be greater. In the months colder than March, when more steam is required for heating, there is every reason to expect a larger gain, although this will be offset by a reduction during the warm weather.

The estimate in the article of an average saving in operating expense of eighteen hundred dollars for six months and six hundred dollars per month for the balance of the year, is conservative, and it would not be surprising if the year to come showed results in excess of the estimate. On the above assumptions the annual saving amounts to more than fourteen thousand dollars, and deducting the usual percentage for interest and depreciation leaves a net balance exceeding ten thousand dollars, which is 23.5 per cent. of the total investment.

From the data given in the article the kilowatt-hours generated averaged 4366 per day. Dividing this by twenty-four, gives 182 kilowatts as the mean load, although at times the maximum demand exceeded 300 kilowatts. It is evident that the electrical load is small for so large a saving, but it only shows what can be done when there is a heating system of sufficient capacity to utilize all or the greater part of the exhaust steam. The efficiency of the combination is approximately sixty per cent.—that is, this percentage of the heat in the coal is used as compared to five to ten per cent. in a noncondensing engine exhausting to atmosphere.

It is surprising how many buildings in Chicago, and other cities for that matter, buy their current. Many of them have boilers for heating, and their electrical load will average as much, if not more, than that of the Federal Building. The coal and ash nuisance cannot be advanced, for they must have coal for heating and but little more will generate the current as well. Unless the owners are given a rate much below what the central station can charge without discriminating against the greater part of its customers, an uptodate generating plant will save them money. What the rate should be to make purchased current desirable may be estimated from the large saving effected in the Federal Building, which was charged 1.9 cents per kilowatt-hour and only 0.9 cent for any current in excess of 100,000 kilowatt-hours per month.

The authorities at Washington are to be congratulated on their insight and the vindication of their belief in a private plant. In Chicago, the Federal Building should serve as an example, showing others what they might do in their own buildings and suggesting an investment which will pay big dividends.

Influence of Volatile Matter on Combustion

The paper on the "Influence of Volatile Matter on Combustion," printed elsewhere in this issue, is of interest in this day of general investigation into methods of burning low-grade fuel and into the design of boiler furnaces.

A furnace with an arch over the fuel bed extending from the bridge-wall to the front wall so assisted in producing high furnace temperature that the rapid distillation of the volatile matter from green coal produced objectionable smoke in large volume. To reduce the quantity emitted in a given time, part of the arch was removed, exposing more of the heating surface to the gases.

On first thought, this seems contrary to correct practice, for it is generally conceded that hot surfaces are most essential to prevent smoke. They are. In this case, however, the nature of the coal was such that its rapid distillation was caused by the heat radiated from the full arch. By exposing more of the heating surface, thus reducing the furnace temperature, the rate of distillation was decreased sufficiently to drive off the gases in volumes small enough to be more or less thoroughly mixed

and burned before condensation in the comparatively cool boiler and flue. It would seem that the same result—i.e., the elimination of dense smoke at high rates of distillation—could be accomplished by using higher settings or greater furnace volume with the full arch. Then there would be a greater area of hot surface with which the gases could make contact and more available space in which to allow the flame to burn out.

Burning high volatile coal successfully is not alone a question of furnace temperature, but of gas volume, gas mixture, furnace volume, temperature and time. For a given furnace with certain facilities for mixing the gases, smoke will be produced if the rate of distillation is high. This rate will be higher, the greater the furnace temperature.

The difference in velocity at which the gases pass through the furnace compared to that at which they are driven off during the distillation process, should be great to allow sufficient time for all the gases and the air to become adequately heated and mixed.

It is gratifying to know that this government is conducting investigations into the burning of high-volatile coals in hand-fired furnaces. Goodness knows there is an urgent need for such knowledge among those who have most to do with the combustion of such fuel.

Removing Obstructions to Business

Under this significant title, a writer in the *Electrical World* discusses the methods of a central station in its campaign of aggrandizement. The article deserves to be commended for its frankness, if nothing else.

After saying, in effect, that by offering a tempting rate, it is easy to sell current where a plant has not yet been installed, the author explains that the real problem is how to induce the prospective customer to scrap, shut down or sell it, when he already has power-generating equipment. Those who offer the principal difficulty are the ones who will not make a change until they have realized something on their investment in plant, so the enterprising company referred to has established a department to buy in old engines as cheaply as possible, sell them at as near the purchase price as possible, and charge the loss to the cost of getting new business. On a total of 123 engines purchased and resold in nineteen months, the average loss was $22 engine—"not a large amount when placed alongside the estimated annual income" from the current sold.

Now comes the interesting part, the disposing of old engines. To quote from this highly enlightening report: "The engine-selling department advertises engines for sale in papers which circulate in the communities it is desirable to reach." (In other words, where current is not for sale.) "Advertisements are not inserted in the company's name. It not infrequently happens that a prospective purchaser of an engine who is on the company's lines will be induced to change his mind and sign an agreement for electric service to do the work an engine was originally intended to do. When a man calls to inquire about an engine, the first question he is asked is where he wants to use it. If his location is beyond the company's sphere of influence, the negotiations proceed. If within the territory supplied with service by the company, the negotiations stop right there and then. No engines are sold by the department where the company's electric service may be obtained." How naive! What business acumen this organization displays!

This policy may be set down as shrewd. So is that of selling shoddy, half-cotton goods for all-wool, or any other merchandizing that deceives successfully, but it is not honest. And it is not professional. It is to just such unprincipled methods of promoting central-station business that we are unalterably opposed. As we have said repeatedly, there is a sufficient legitimate field for the central station to make recourse to any questionable practices unnecessary. The alarming revelation is that such a raw proposition can be boldly exploited in public print, apparently without fear of arousing the disgust and condemnation of a people who pride themselves in a love of fair play. It is high time that those who are jealous of the good name of American engineering resented such insults.

Gravity Delivery of Coal

While gravity delivery of coal into power-plant yards has recognized advantages, the saving per ton in the cost of handling fuel in this way, as compared with mechanical or hand trimming, depends upon many factors. Chief among these are the amount of coal storage required, the difference in level between coal yards and side tracks, and the amount of fuel to be handled in a given time. The cost of track elevation and of placing coal cars at the desired level for economical dumping must, in many cases, be considered when comparing mechanical delivery with gravity dumping.

In a recent instance, an analysis of the fuel-handling problem showed that the delivery of coal by gravity from cars on a track fifteen feet above the yard saves the operating company from fifteen to twenty cents per ton as compared with the fixed and operating charges on a fifteen-thousand-dollar coal-handling plant which would otherwise be needed. If there were no difference in elevation between yard and track, and if no plant were installed for handling the fuel, the investigation showed that the cost of trimming the coal by hand from cars into the yard would run from twenty-five to thirty cents per ton. The company uses about thirty-five hundred tons of coal annually.

These differences are important and indicate that in the study of such problems and deduction of unit handling costs for plants of various sizes and designs, the engineer of analytical bent will find much that is interesting and profitable.

The Pity of It!

Regardless of whether a war is justified or not, or which side, if either, is in the right, both sides are always punished; and usually disinterested noncombatants suffer as well. War cannot always be avoided and, perhaps, more times than not, eventually proves to be of real good to humanity. Nevertheless, it is an economic waste in several ways. The cartoon in this issue brings out one of these ways—the hindrance of engineering and industrial progress—which is generally lost sight of in the contemplation of war's more horrible consequences, the cost in lives and property destroyed.

Correspondence

Backfiring through Intake

Mr. Demorest's statement in the Feb. 14 issue, that a rich mixture will backfire in the manifold is entirely contrary to my experience. The statement should hold true, according to his reasoning, that the charge hangs fire during the expansion and exhaust stroke; it does not work out in practice.

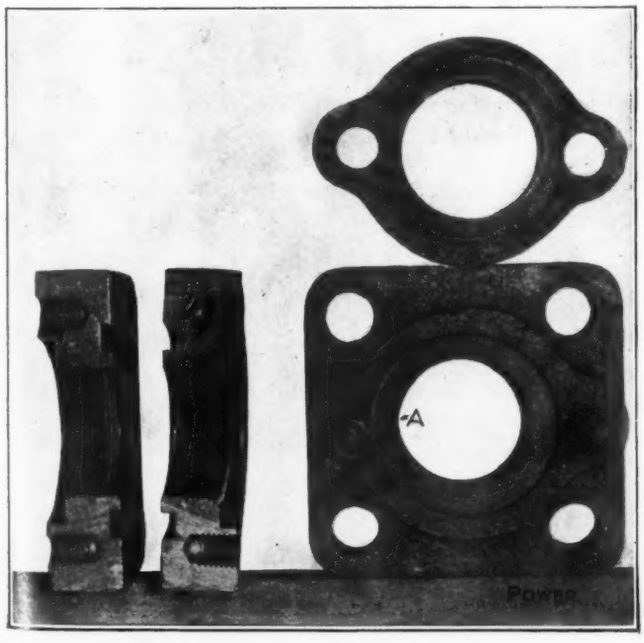
He also states that it is a common mistake to attempt to distinguish between an over-rich and an over-lean mixture. This might have reference altogether to an automobile engine, which would hold true only when the engine was running idle. If the throttle were suddenly opened with an over-rich mixture, the engine would miss and fire in the muffler. The difference is quite noticeable on a stationary gas or gasoline engine.

N. E. Woolman.

Kittanning, Penn.

Stopping an Ammonia Leak

After cleaning and overhauling a small refrigerating plant and recharging the system, it was discovered that there was a small ammonia leak on one of the 2-in. flanges on the separator leading to the condenser. As tightening it did not stop the leak, the flange was uncoupled and a new gasket put in. After trying again it still leaked, and upon close investigation it was noticed that the flange appeared to be slightly curved. Scraping around the stud at *A* of the packing gland it was found that the flange was cracked and would not tighten evenly all around. The flange was then replaced by one without a gland. After this side was repaired and the pressure applied to it the flange on the opposite side of the separator showed the same trouble, and on trying to tighten it, a crack appeared in that one also.



Showing the Cracked Flange

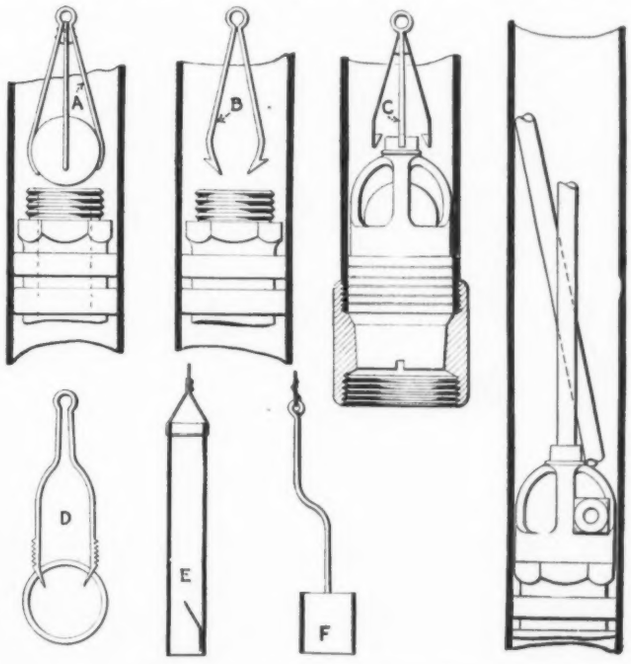
After this was repaired I removed the 5/8-in. studs and sawed through the solid side of one of the flanges, the two halves showing in the left of the illustration, which shows the flange to be poorly designed. The stud holes appparently weaken the flange at those points. No further trouble was experienced with the solid flanges that replaced them.

L. M. Johnson.

Emsworth, Penn.

Troubles with Deep Wells

Our driven wells are several hundred feet deep and water is pumped with a deep-well and a one-geared pump; the cylinders are at a depth of 275 ft. The sucker rods are 2¼-in. size and the plungers are single acting, of the ball-valve type. When anything goes wrong 275 ft. down, one has his work cut out, especially if there is but one source of water supply.



Tools Used in Deep-Well Repairs

The illustration shows how the bonnet pulled from the plunger leaving the ball on top. The threads of the bonnet were stripped so a tool was made to get the ball, as shown at *A*. Then the tool shown at *B* was made and used to get the rest of the fitting.

At another time something got under the ball of the foot valve and in trying to pull it in the regular way the spud broke, but was finally got out with the tool shown at *C*. The tool *D* was made to get the washer rings out when the lower bonnet came off with stripped threads, and the rest of the valve was removed by using the tool *B*.

Once the entire end of the cylinder stripped and the foot valve went to the bottom of a 600-ft. well. A heavy gin pole was erected, two heavy double blocks and some 1¼-in. rope were obtained, and four horses were used to pull the pipe up, using the tool *C* to clutch the cylinder. The valve was fished from the bottom of the well and the ring riveted back on the bottom of the cylinder. We then put everything back only to lose it again and then had to put on a new cylinder.

At another time the rods broke at the crosshead, the nut from the pin dropped to the bottom and the rods broke again 10 ft. down. This piece went to the bottom also. The piece of rod was got out with a short length of 3-in. pipe with a flat spring arranged inside, as at *E*. A nut which was left loose kept catching in the space between the ends of the pump pipe at the couplings. After making a magnet and failing to get the nut, because the nut became magnetized and would stick to the pipe, a piece of stove pipe *F* was arranged to fit inside the 6-in. pipe, and slip down over the nut. Then a piece of 4-in. pipe with a flat spring was let down over the rods and the whole pulled up together. The piece of stove pipe kept the nut from falling over as each coupling in the pipe was passed.

C. A. Scott.

Wales, Wis.

Gas Explosion in Muffler Pit

Few people realize the explosive power of gas when mixed with a sufficient amount of air. A man who handles dynamite is following a hazardous occupation, and engineers in charge of gas engines go on day by day handling or dealing with an explosive that is almost if not altogether as dangerous.

Result of the Explosion

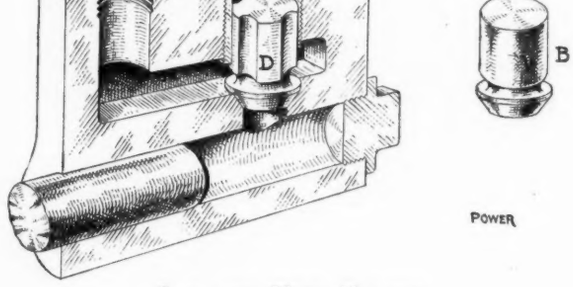
This force, when properly applied to the piston, is tamed down sufficiently to be turned into useful work, but let something go a little out of the ordinary, as, for instance, a certain amount of gas gets by the engine and finds its way into the exhaust pit, as it did in this case. Then when a spark gets to it, the results are as illustrated.

The engine had been shut down over Sunday and gas had accumulated in the muffler, or found its way through while the engine was being started. Three or four attempts were made before the engine fired. Then there was a violent explosion in the muffler, the concrete cover was thrown every which way, and the wall over the pit was cracked. The engine was not damaged, and was run through the week without a cover on the pit. The window was raised and canvas put in to keep the vibration set up by the exhaust from breaking the glass.

Coffeyville, Kan. P. A. Gett.

Repairs Should Duplicate Originals

Mistakes in making repair parts and failure to observe closely and duplicate the originals often cause annoyance and loss. For example, a new discharge valve was needed for a pump used for hydraulic elevator service. The repair shop apparently got out a nice job on the new valve and the upper cap, but the guide stem *B*



Old and New Valves

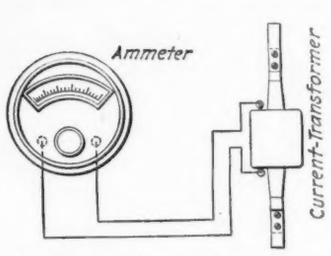
was made round and fitted closely in this cap, so that when the pump was started after the new valve was put in, it worked a few strokes, and then failed, because the valve would remain open, or up in the cap, on account of not having vent around the stem to equalize the pressure. The old valve had flutes cut in the stem, as shown at *D*. After two slots were filed in the new stem, there was no further trouble.

C. R. McGahey.

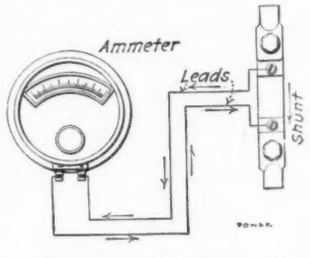
Baltimore, Md.

Ammeter Trouble

An ammeter that would itself carry the total current to be indicated for large generators, would be prohibitive in size. Accordingly, it is customary to have the ammeter carry only a small proportion of the current that



Ammeter Connections for Alternating-Current Circuit



Ammeter Connections for Direct-Current Circuit

it indicates, but the scale is marked as if the whole current were going through the meter. In alternating-current work, this is accomplished by means of a current

transformer, as indicated in Fig. 1. In direct-current work, a low ohmic resistance is cut into the circuit the current of which is to be measured; the ammeter being connected in parallel with this resistance. The proportion of the current taken by the ammeter depends upon the resistance of itself and leads as compared with that of the shunt. This being true, lead resistance is as important in fixing the ratio of current division as is ammeter resistance and only leads of a certain resistance will permit correct indications on the meter.

In a case in mind, a short-circuit behind the switchboard, burned the coiled-up ammeter leads so that they had to be replaced. An equal length of silk-covered lamp cord was used to replace them; but its cross-section was so much greater than that of the original leads, that the ammeter indicated about 40 amp. high, a difference that the engineer noticed because he knew what the load should be when certain switches were closed.

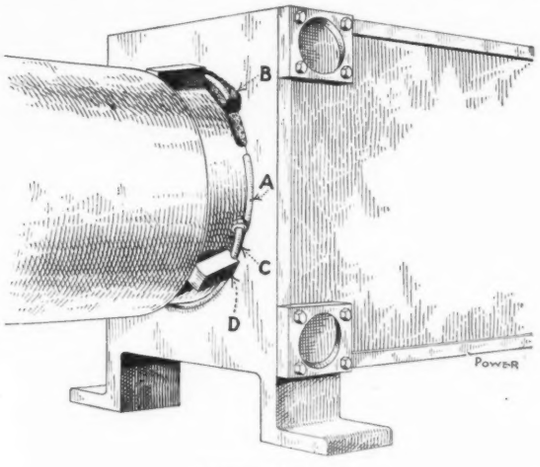
To check his conviction, he cut the ammeter into series with another one which he knew to be about right. With a steady current flowing through both meters and their shunts, he lengthened the faulty leads and found that this decreased the error; so he got a longer piece of the same cord, skinned it for an inch or so at intervals of a foot, to make trial connections easy, and by trial found the length that would cause the two meters to indicate the same; he then tinned the ends, flattened them with a hammer and drilled them to make a terminal and permanently connected them; and everything was all right. When the leads were too low in resistance, the ammeter took more than the proportion of current for which its scale had been made, so the scale was useless unless the error was known.

J. A. Horton.

Schenectady, N. Y.

Leaky Cylinder Joint

The crank-end cylinder head on the high-pressure side of a 30 and 60 by 54-in. compound engine began to leak soon after the engine was erected. The leak extended about one-third of the way around the head, and also showed under the nuts. To repair it by removing the



Joint Clamp

cylinder would have been quite a job, and tightening the nuts would not stop it.

The bolts joining the cylinder to the frame were on the inside. A small groove was chipped around the edge of the flange and a copper wire calked into it, as at *A*, and overlaid with asbestos wicking, at *B*.

A ½-in. rod *C* was bent to encircle the frame, having an eye in one end through which the other end passed, to be drawn up with a nut.

Three small spanners *D* were used to force the rod up against the head, by driving them in between the shoulder of the frame and the rod. The illustrations show the parts all assembled ready to be tightened, and after the job was done. Drawing up the nut so that the rod was drawn tightly around the flange, and at the same time driving the spanners, resulted in forcing the asbestos tightly into the corner.

After the nuts were taken off and cupped out in a lathe and replaced with asbestos wicking wraped around the bolts, the job was a success. It required but little time and practically no expense. Copper wire is hardly necessary, as the wicking would fill the space just as effectively. The writer has often made use of this method in stopping leakage around bolts.

Joseph Stewart.

Hamilton, Ohio.

V-Block Belt Cures Slipping of Governor Drive

Fig. 1 shows the design of a troublesome governor drive, due to slipping and breaking ropes, jumping out of their grooves, getting crossed and tangled. Furthermore, it was next to impossible to keep all of the ropes under the same tension, due to stretching.

Rawhide and other kinds of ropes were used, but while

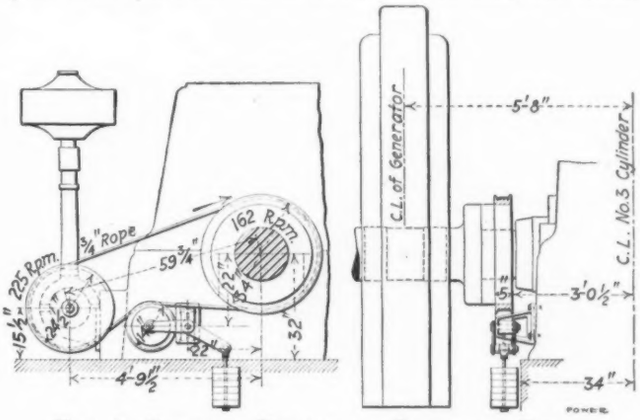


Fig. 1. General Design of Governor Drive

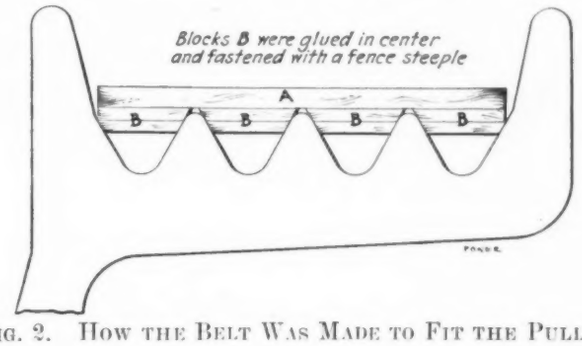


Fig. 2. How the Belt Was Made to Fit the Pulley

the rawhide rope gave the most satisfactory service, it did not prove reliable.

To make the governor drive reliable, a belt *A*, Fig. 1, was cut 3¾ in. wide. Strips of belting were then cut,

with beveled edges to conform to the grooves in the pulleys, on a band saw having a tilting table.

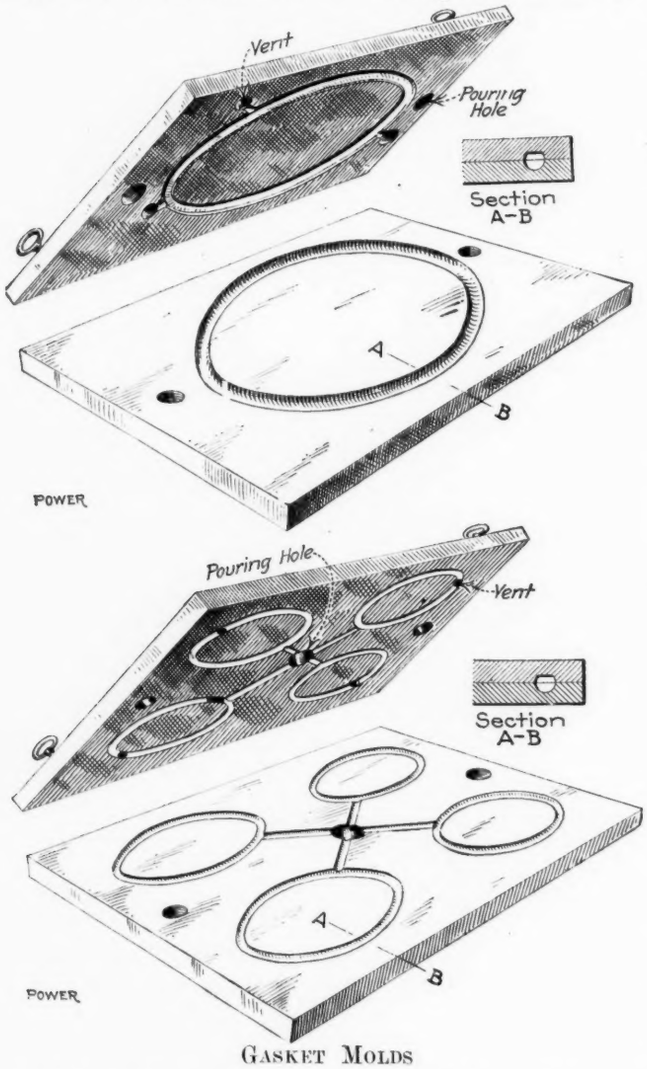
These strips *B*, Fig. 2, were cut into pieces 1½ in. long and glued to the belt. Each was then secured permanently by a wire fence staple sufficiently long to just reach through the block and belt and be clinched The belt is thus kept pliable. There were no blocks at the ends, but they were used at the joint to complete the belt. The idler grooves were filled with babbitt and turned down. This belt has been giving satisfactory service, and did not cost much.

W. G. WEBSTER.

Kittanning, Penn.

Lead Boiler Gaskets

The cost of gaskets of all sizes for boilers can be materially reduced by making them of lead at the plant and using the old lead over again in molds as shown. The molds are of cast iron with a milled groove of the desired size and shape in one plate, usually a half-round cross-section; the other may be only a flat plate held in place by dowels and capscrews. A ladle and a forge complete the outfit. The old lead is melted and made up by new pig lead, which costs about seven cents per pound. About 60 per cent. of the old is recovered, so that the cost of new joints is not excessive. Two men can make several hundred in a day.



GASKET MOLDS

These gaskets give excellent results when put into service. They are soft and easily tightened if leaking starts, which sometimes happens when the boiler is first fired up. The writer has seen lead gaskets used on the rear end of a Heine boiler, which when cold permitted the nuts on the tube caps to be turned by hand; but the joints did not leak after the boiler was fired up again.

One plant of about 5000 hp. has 350-hp. Stirling and 450-hp. Heine boilers carrying 165-lb. steam pressure, with 100-deg. superheat, on which all hand and manhole gaskets are lead and molded in the plant. They were ⅜ in. thick, ⅞ in. wide and ⅜x½ in. respectively. The plates are easily made where a milling machine can be used.

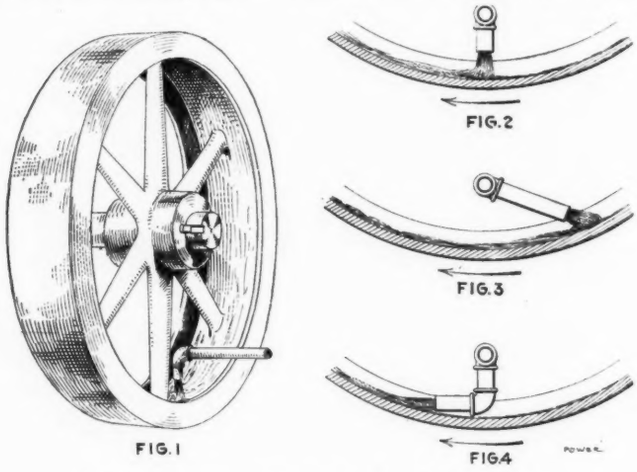
J. C. HAWKINS.

Hyattsville, Md.

Cooling Prony Brake

An item commonly overlooked in testing steam engines, motors, etc., with a prony brake is the kinetic energy which the brake wheel imparts to or receives from the cooling water.

For example, in a brake test of a 50-hp. steam engine where 1000 lb. of water is used per hour for cooling the brake wheel, if the cooling water is discharged into a trough-shaped rim of brake wheel in about the manner indicated in Figs. 1 and 2, some of the energy will be absorbed in bringing the water up to the velocity of the



METHODS OF APPLYING COOLING WATER

rim. On the assumption that the rim velocity is a mile a minute, or 88 ft. per sec., it may be seen from the formula

$$\tfrac{1}{2}\, Mv^2 = ft.\text{-}lb.\ per\ sec.$$

that the retardation would amount to about $^1/_{20}$ of 1 hp. To deliver the water in direction contrary to that of motion of the rim, as shown in Fig. 3, the retardation would be greater, depending on the velocity of the water and roughness of the wheel. Though this would be small as compared with the entire output of power, it is evident that for elimination of these errors, the water should be applied as indicated in Fig. 4—i.e., in the direction of motion of the wheel, and, as far as possible, the water should have the same velocity as the rim of the wheel. It is also evident that no method should be used for scooping out the water that would tend to retard the brake wheel.

New York, N. Y. S. F. WILSON.

Inquiries of General Interest

Lap and Lead—What is meant by lap and lead of a D-slide valve?

C. F.

Lap of a valve is the distance which it overlaps the port when the valve is in its middle position. Lead is the distance which the valve has uncovered the inlet port when the piston has reached the end of its stroke.

Wider Strap of Double-Strap Joint on Inside of Boiler—In an ordinary butt and double-strap boiler joint, why is the wider strap placed on the inside of the boiler?

T. J. L.

In butt and double-strap boiler joints, as ordinarily designed, the pitch of the outer rows of rivets is too great for a calking pitch; and as calking is done from the outside of the boiler, the wider strap is placed on the inside and suitable calking pitch of an inner row of rivets is utilized for the calked edges of a narrower strap placed on the outside of the boiler.

Electrical Conductivity of Aluminum—What is the relative electrical conductivity of aluminum and of copper wire and the relative cost for equal conduction?

E. S. C.

Hard drawn aluminum wire, 98 to 99.75 per cent. pure, has a conductivity of 55 per cent. to 64 per cent., copper being taken as 100 per cent. Aluminum wire of 62 per cent. conductivity is the generally accepted standard and when of that conductivity and purchased at 2.13 times the price of copper per pound, will give the same length and conductivity for the same expenditure.

Increasing Thickness of Babbitting—How would increasing the thickness of the babbitting of a pair of eccentric straps and use of thicker shims affect the lead of a direct-connected slide valve?

C. S. F.

The effect would be the same as increasing the length of the eccentric rod or of the valve rod, i.e., the valve would have more lead on the crank end and less lead on the head end of the cylinder, but all the events of the valve action would be restored by shortening the length of eccentric rod or of the valve rod by the amount of thickness added to the eccentric-rod babbitting.

Altitude Indicated by Water-Pressure Gage—What variation of depth of water in a tank will be due to a difference of pressure of 5 lb. per sq.in. shown on a pressure gage connected with the discharge pipe from the tank?

E. P.

To eliminate errors due to losses of pressure from friction of water flowing in the discharge pipe, the pressure readings should be taken when there is no flow taking place in the pipe to which the gage is attached. At ordinary temperatures of the water each pound difference in pressure would indicate a difference of 2.309 ft. and a difference of 5 lb. would indicate

$$5 \times 2.309 = 11.545 \text{ ft.,}$$

or about 11 ft. 6½ in.

Coal per Horsepower-Hour—In a plant where the weekly consumption of coal for the generation of power amounted to 40,407 lb., one engine (a) ran 15 hr. developing an average of 132 i.hp., another engine (b) ran 32 hr. developing an average of 78 i.hp., and a third engine (c) ran 55 hr. developing an average of 112 i.hp. How much coal is used per horsepower-hour?

During the week there would have been developed

By engine a $132 \times 15 = 1980$ hp.-hr.
By engine b $78 \times 32 = 2496$ hp.-hr.
By engine c $112 \times 55 = 6160$ hp.-hr.

and the total development was 10,636 hp.-hr. Therefore, the coal used was

$$\frac{40{,}417}{10{,}636} = 3.8 \text{ lb. per hp.-hr.}$$

Radiating Surface of Steam Pipe—How many lineal feet of 1- and 1¼-in. steam pipe are required for 1 sq.ft. of radiating surface?

E. A. B.

Commercial 1-in. pipe has an outside diameter of 1.315 in. and an outside circumference of

$$1.315 \times 3.1416 = 4.131 \text{ in.}$$

hence for 1 sq.ft. of radiating surface

$$\frac{144}{4.131 \times 12} = 2.905 \text{ lin.ft.}$$

of 1-in. pipe is required. Commercial 1¼-in. pipe has an outside diameter of 1.66 in. and an outside circumference of

$$1.66 \times 3.1416 = 5.215 \text{ in.}$$

Therefore, for 1 sq.ft. of radiating surface,

$$\frac{144}{5.215 \times 12} = 2.301 \text{ lin.ft.}$$

of 1¼-in. pipe is required.

Steam from a Cubic Inch of Water—How many cubic inches of dry steam can be evaporated from a cubic inch of water at 62 deg. F.?

W. C. C.

The volume occupied will depend on the pressure. A cubic foot of water at 62 deg. F. weighs about 62.36 lb. and referring to Mark's and Davis' steam tables it may be found that the density of a pound of dry steam at 14.7 lb. absolute or atmospheric pressure is 0.03732 lb. per cu.ft.; at 65 lb. absolute, or about 50-lb. gage pressure, the density is 0.1503 lb.; and at 115 lb. absolute, or about 100 lb. gage pressure, the density is 0.2577 lb. per cu.ft.

Therefore, when 1 cu.in. of water at 62 deg. F. is evaporated into dry steam there will be formed

$$\frac{62.36}{0.03732} = 1670.9 \text{ cu.in.}$$

of steam at atmospheric pressure;

$$\frac{62.36}{0.1503} = 414.9 \text{ cu.in.}$$

at 50 lb. gage pressure; and

$$\frac{62.36}{0.2577} = 241.9 \text{ cu.in.}$$

at 100 lb. gage pressure.

Locating Pulleys and Floor Holes for Quarter-Turn Belt—How may the locations of pulleys and belt holes in floors be determined to transmit power by quarter-turn belt from one horizontal shaft to another at right angles to it?

G. W. E.

Locate a point on each shaft plumb with the center line of the other shaft. The middle of each pulley is to be placed to one side of the plumbed point on its shaft a distance equal to the radius of the pulley on the other shaft, and each pulley is to be located in direction away from the plumb point on its shaft which will be the same as the direction of rotation of the farthest side of the other pulley. It must be borne in mind that the belt is to pass from the top of the upper pulley over the farther side of the lower pulley and around its lower side, and thence to the farthest side of the upper pulley and over it. Knowing the direction to be taken by the belt, the belt holes in a floor can be laid out by a scale drawing or their location can be determined by stretching a line around the pulleys in the direction to be taken by the belt, and finding by trial and error the direction and location required for small holes bored through the floor which admit of free passage of the line when stretched over different parts of the faces of the pulleys. The clearances required for the pulley side of the belt are thus shown and from them the floor holes are readily located and determined with due allowance for thickness, flaring and waving of the belt.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necesary to guarantee the good faith of the communication and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--VI

Last Lesson's Answers

21. Consider the point B as a free body. In Fig. 22 let the line AC represent the total vertical load $= (P + W) = 1200$ lb. The line BC drawn parallel to the rod BC will represent the tension T in the rod, and AB

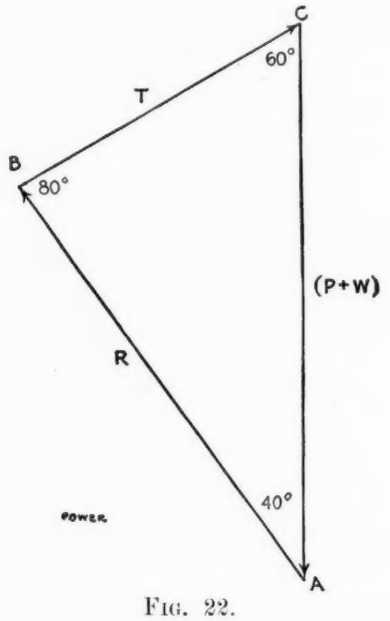


Fig. 22.

drawn parallel to the strut AB will represent the compression R in the strut. The angle CAB being 40 deg. and the angle ACB 60 deg., the angle CBA must equal $(180 - 60 - 40 =)$ 80 deg.

From the law of sines

$$\frac{T}{\sin 40^\circ} = \frac{(P + W)}{\sin 80^\circ}$$

or

$$T = \frac{(P + W) \sin 40^\circ}{\sin 80^\circ} = \frac{1200 \times 0.643}{0.985} = 783 \text{ lb.}$$

22. Again applying the law of sines there results the equation,

$$\frac{R}{\sin 60^\circ} = \frac{(P + W)}{\sin 80^\circ}$$

or

$$R = \frac{(P + W) \sin 60^\circ}{\sin 80^\circ} = \frac{1200 \times 0.866}{0.985} = 1055 \text{ lb.}$$

23. The reaction counteracting the tension T is the strength of the rod which is dependent upon the size and material of the rod. Likewise the strength of the strut AB produces the necessary reaction to counteract the thrust R.

24. In Fig. 23 draw the forces P_1, P_2, P_3 and P_4 with the directions and magnitudes given in problem 10. Draw the force P_5 equal and opposite to the resultant which was found to be 144 lb. Starting with the point O and using the force P_5 as a base line draw a force polygon, making OA equal and parallel to P_5; AB equal and parallel to P_1; BC equal and parallel to P_2; CD equal and parallel to P_3; and the line OD equal and parallel to P_4.

25. All the forces must be in equilibrium since they can be represented by the sides of the polygon $OABCDO$ taken in order. If the line OD does not come out equal and parallel to the force P_4 there has been an error somewhere in the student's work.

Parallel Forces

Parallel forces are those which act at different points of a body and have their lines of action parallel. If the forces act in the same direction they are called *like forces;* and if they act in opposite directions they are called *unlike forces.* The resultant of two like forces is equal to the *sum* of the forces and *acts in the same direction* as the forces; the resultant of two unlike forces is equal to the *difference* of the two forces and *acts in the direction of the greater force.* In the case of like

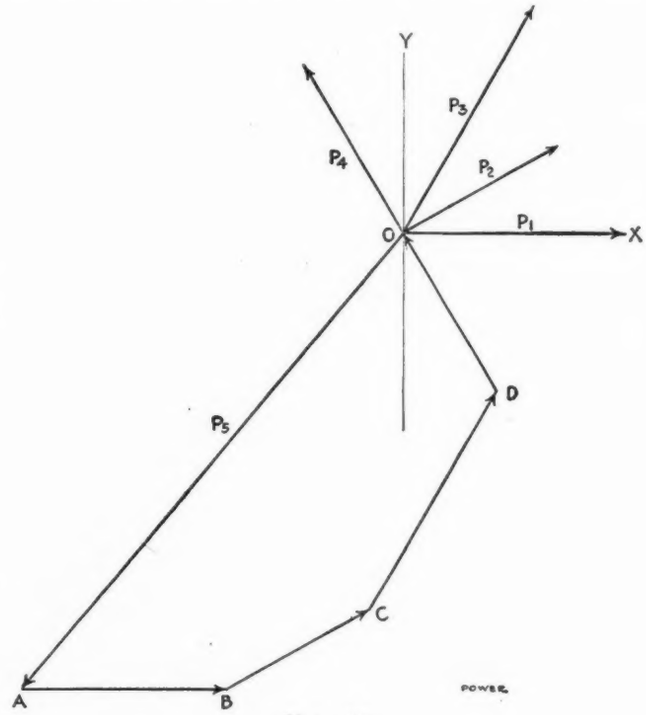


Fig. 23.

forces the resultant will lie between the two forces and in the case of unlike forces the resultant will lie outside of both forces. The above laws are almost axiomatic, or self-evident, and no proof will be given at present.

Parallel forces are simply an extension of the parallelogram law in which case the point of meeting of the forces is at an infinite distance from the body on which the forces are acting. In Fig. 24a the resultant R of the two like forces P_1 and P_2 equals $(P_1 + P_2)$ and acts

at a point B such that the distances a and b are inversely proportional to the forces P_1 and P_2, or

$$\frac{P_1}{P_2} = \frac{a}{b}$$

In Fig. 24b the resultant R of the two unlike forces P_1 and P_2 is equal to $(P_2 - P_1)$ and acts at the point A such that

$$\frac{P_1}{R} = \frac{a}{b}$$

Moment of a Force

Concurrent forces acting on a body tend to produce motion in the direction of the resultant force. Such motion is spoken of as one of translation, since the motion is in a straight line. Another kind of motion is that of rotation in which case the given force tends to rotate the body about a fixed axis. Thus the tension in a belt causes the pulley, on which it is acting, to rotate about its fixed center. Hence:

The tendency of a force to produce rotation of a body about a definite or imaginary axis is called the moment of that force.

The *measure* of the *moment* of a force is the *product of the force times the perpendicular distance from the given axis to the line of action of the force.* Generally the distances will be expressed in feet, the forces in pounds and hence the moments will be given in foot-pounds.*

For convenience in the solution of problems, moments tending to produce rotation in the direction of the hands of a clock will be taken as positive (+) and all moments tending to produce counter-clockwise rotation as negative (—).†

Couples

Two equal and opposite parallel forces acting at different points of a body produce what is known as a

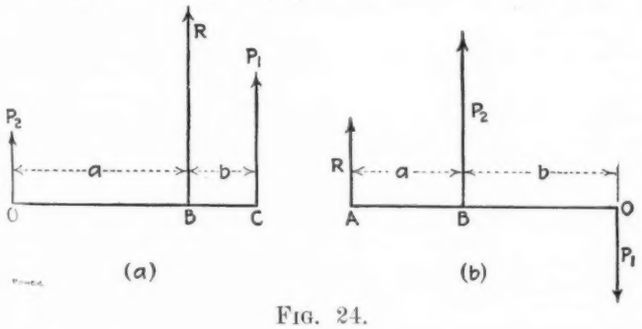


Fig. 24.

couple. The perpendicular distance between the forces is called the *arm* of the couple. Since the forces are equal and opposite in direction the resultant force is zero and therefore the action of a couple is not to produce translation, but to produce, or tend to produce, rotation of a body. The moment of a couple is equal to the product of one of the forces times the perpendicular distance between the forces, or times the arm of the couple. No single force can balance a couple and hence the equilibriant of a couple is another couple equal and opposite to the given couple.

*Many writers on mechanics prefer to use the term pound-feet for moments, to distinguish from the unit of work which is the foot-pound.

†Here again writers are not uniform, as some prefer to use clock-wise rotation as negative. In all problems in this course clock-wise rotation will be taken as positive.

The moment of a couple remains constant, irrespective of the point about which the moments of the forces are taken. This may be proved as follows:

In Fig. 25, let the equal and opposite forces P_1 and P_2 produce a couple whose moment arm is CB. The moment of this couple about the point O equals

$$P_1 \times OB + P_2 \times OC$$
$$= P_1 (OB + OC) \text{ (since } P_1 = P_2)$$
$$= P_1 \times CB$$

Now assume some other point S. The moment of the couple about this point

$$= P_1 \times SB - P_2 \times SC$$
$$= P_1 (SB - SC) \text{ (since } P_1 = P_2)$$
$$= P_1 \times CB \text{ (for } SB - SC = CB)$$

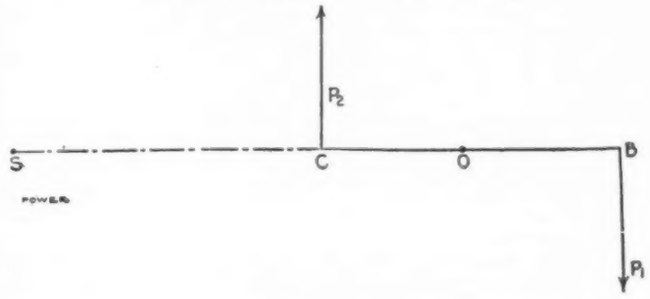


Fig. 25.

Therefore, the effect of a couple upon a rigid body is unaltered if it be transferred to any plane parallel to its own, the arm remaining parallel to its original position.

Study Questions

26. Two men carry a weight suspended from a horizontal pole. The one man exerts a pressure of 40 lb. and the other 60 lb. If the distance between the men is 10 ft., what is the magnitude and location of the weight? Neglect the weight of the pole.

27. A man turns the crank of a windlass. Is there a couple produced? If so, where is the second force?

28. The handle of a grindstone is 12 in. long. A man exerts a pressure of 30 lb. in the direction of motion of the handle. What is the turning moment produced?

29. A prony brake is clamped to the pulley of a motor. What is the turning moment or torque of the motor when a given armature current produces a net pull of 10 lb. at the end of the brake arm? The length of the brake arm is 24 in.

30. In question 9, Lesson II, determine the effective moment tending to rotate the crankshaft. Does this moment remain constant during a complete revolution of the engine? Assume the engine stroke to be 18 in.

High-School Boys in the Shops—Real industrial training that prepares for real jobs is described in a bulletin on the coöperative plan at Fitchburg, Mass., issued by the United States Bureau of Education. Boys in the Fitchburg high school, who attend alternate weeks in school and shop, are made to feel that their vocational training is serious business.

De Laval Pump for University of Illinois—The hydraulics laboratory of the University of Illinois has added another piece of apparatus to its equipment, there being installed a 4-in. three-stage De Laval centrifugal pump. It will be driven by a 50-hp. Westinghouse, variable-speed induction motor and will be capable of giving a discharge of 275 gal. per minute against a head of 400 ft. The pump will be so arranged that water can be drawn from the laboratory standpipe into the pump, and in this manner the total available head of 450 ft. can be had.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Prof. Kent recently told the Sibley College students that the qualifications necessary for the position of general manager are "health, education, special knowledge, tact, energy, industry, personality, initiative, aggressiveness, and a degree of laziness." Omitting the last ingredient, this may be the reason for the scarcity of twenty-five-thousand-dollar-men.

"A kiss is an operation performed on another's body, requiring under all circumstances the recipient's sanction."—German supreme court decision.

Some fifty people have suggested this item as a "spill," 25 of whom are men, and for whom there is nothing doing! But in these days of feminism we are in doubt how the—er—others are going to act. Anyhow, we claim the right of appeal, your honor—and the line forms on the right.

The Canadian Pacific R.R. has added a "scout" to its staff. His duty is to "travel over the road and discover those employees who are especially worthy of advancement." Hail to the scout! Bet a railroad spike he'll be kept busy squaring himself with those who are worthy—and who get sidetracked from the Advancement division.

Contemporary announces that Frank Gilbreth has started a "Fatigue Museum." This listens like the name for a tramp's "hotel." It really is a museum showing devices that affect the well-being of the workman.

"Safety First" is printed on the pay envelopes of the employees of a lighting company. Some of these boys must have opened theirs before reaching home and dallied by the wayside. The advice is: "Don't go into dangerous places. Don't attempt to make adjustments. Don't disregard warning signs. Warn a man when danger is near. In case of doubt, adopt a safe course." All this preachment would be useless in a "dry" town.

Brother Rockefeller, among his many practical philanthropies, has established a million-dollar fund for research work of benefit to us humans. The government is helping the hogs and the sheep, so Brother John thinks he might as well be the goat and do something more for us lambs.

Reckon there's right smart white folks in the Anderson (S. C.) Cotton Mills. The other evening, a tol'able time after sundown, they-all had an ornery little fire "in the engine of the mill," says the local paper (though Brother Wright asseverates 'twas really the roof of the boiler house). But lordy, honey! time the Marthy Washington Hose No. 68 gets projectin' round the mill, the home talent and the comical sprinklers done squalshed the fire so doggone quick the Marthy Washingtons didn't even get to pumpin'—and they're some critters at a fire.

Brooklyn's Polytechnic Institute has a Mermaid Club—and has had for 10 years. The original club of this name was started in London by our old friend Walt Raleigh, and was frequented by Ben Jonson, Beaumont and Fletcher, and perhaps Mad Will. Our "Webster" further says a mermaid's a siren, and a—something worse. Probably Noah (meaning Webster) had in mind some of the original members when he made that third definition. These "Poly" boys (both the old and the young) are just regular chaps, and good fellows.

What a pity it is that religious bias and race prejudice so largely influence us. Nowhere on God's green earth are there such golden opportunities to practice the "live-and-let-live" idea than in these United States! Our country is the haven of the oppressed, the school of the unlearned—the one big chance to get ahead on our own initiative, and be something! At one time or another, we were all "foreigners," weren't we?

And because many of us can't agree as to how a man shall do his praying, if any, and because we can't see how the Almighty committed the mistake of creating any other race than our own, we go on sneering, and despising, and exhibiting our narrow souls and our mean prejudices. Say, let's buck up, and see if we can find SOME good in them all. Let's cultivate the true American spirit and be big, and more broad, and more kindly!

Influence of Volatile Matter on Combustion*

By SAMUEL B. FLAGG†

In handling the combustion problem, the difficulty of obtaining an intimate mixture of air and combustible gases before they come in contact with surfaces which lower the temperature below the ignition point, is the greatest to be overcome. As to the proper furnace construction to bring about this mixture, we are today in need of information.

Investigations by H. C. Porter and F. K. Ovitz‡ and by others show decided differences in the quantities of smoke-producing volatile matter distilled or driven off from different coals, or even from the same coal under different conditions of heating. Curves showing the quantities determined for several coals are shown in Fig. 1.

To illustrate, if it is assumed that Pocahontas, Connellsville, Zeigler (Illinois) and Dietz (Wyoming) coals can be burned with the same overall efficiency, the quantities of

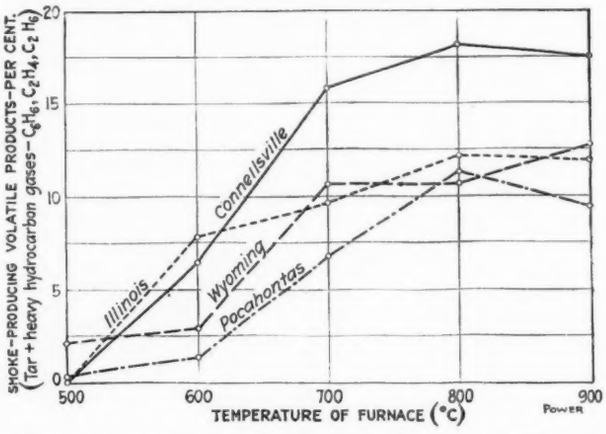


FIG. 1. QUANTITIES OF SMOKE-PRODUCING VOLATILE DISTILLED FROM SEVERAL COALS

these coals required to evaporate a given quantity of water will be as 1: 1.05, 1.23: 1.39. If the temperature of the furnace in which these coals are burned is about 1650 deg. F., the quantities of smoke-producing volatile matter driven off will be as 1: 93, 1.55: 1.86. The furnace and the method of operation must, therefore, be adapted to take care of nearly twice the quantity of smoke-producing gases and vapors if Connellsville coal is to be used instead of Pocahontas.

The problem is further complicated in that the volatile matter of the Connellsville coal is of a different character than that of Pocahontas and requires more air for its combustion. For instance, the experiments show that the quantity of tarry matter, which is most difficult to break down and completely burn, from the Connellsville coal would be almost double that from Pocahontas. If the Zeigler (Illinois) and Connellsville coals tested by these men be compared in a similar way, it will be found that, although the amount of Illinois coal required to evaporate a certain number of pounds of water will be more, the quantity of smoke-producing volatile matter from it will be only 80 per cent., and the quantity of tarry matter only 95 per cent. of that from the Connellsville coal. From these few figures it is evident that the character of the coal increases or decreases the difficulty of obtaining complete combustion.

In plants which are mechanically stoked, the lessening or the prevention of smoke emission is accomplished largely through the decrease of the rate of heating of the coal or through the better mixing facilities, or both.

In some respects the problem of obtaining complete and at the same time efficient combustion is much more difficult in the case of hand-fired furnaces than where the stoking is mechanically done. In spite of this, however, the design of mechanically fired furnaces has been given the greater amount of real scientific study.

Some four years ago the Bureau of Mines, realizing the need of more complete information concerning the effect upon efficiency and smoke emission of differences in methods of

*A paper read before the Cleveland Engineering Society.

†Engineer of the United States Bureau of Mines.

‡"The Volatile Matter of Coal," H. C. Porter and F. K. Ovitz, Bureau of Mines Bulletin 1, 1910, pp. 32 and 34; also "The Smokeless Combustion of Coal in Boiler Furnaces," D. T. Randall and H. W. Weeks, Bureau of Mines Bulletin 40, 1912, pp. 173 and 174.

firing, and of certain features of design of hand-fired furnaces, planned a series of tests which have since been carried out. A report of the tests and the results obtained is now in press.

Figs 2, 3 and 4 show the several arrangements of the setting with which tests were conducted, and Table 1 gives the principal results. With each arrangement of setting, trials were made to ascertain the effect of the method of firing, and with some of them to observe the effect of supplementary air admitted into the furnace or combustion chamber. The rate of combustion was practically the same—approximately 15 lb. per square foot of grate per hour—for all tests, and the coal, although it was not all produced at one time, was all slack coal from the Pittsburgh seam and of the same general character throughout. A general discussion concerning the effect of the several features of these furnaces and of the method of firing is given in the report mentioned, and it will soon be ready for distribution. At different times in these experiments, each of the three following methods of lessening smoke were employed: Extra air, better mixing facilities, and decreasing the rate of heating. The effects of each in decreasing smoke are evident.

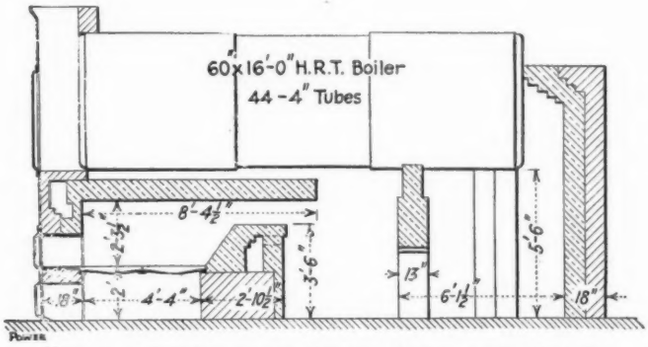


FIG. 2. SETTING WITH BRICK ARCH OVER GRATE

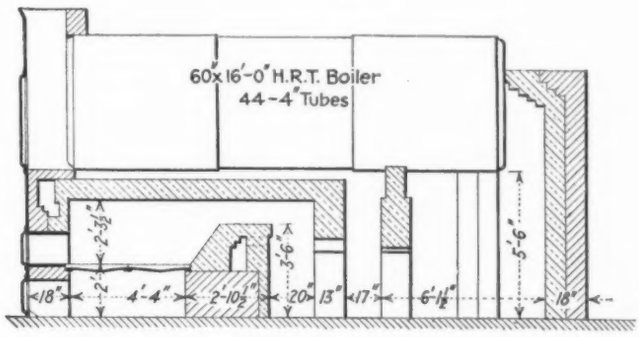


FIG. 3. SETTING WITH FURNACE AND DEFLECTION ARCHES

To determine just what changes are taking place in a furnace is always a difficult, if not impossible, task. On account of the observed difference in smoke emission under the different firing conditions, however, an effort was made to analyze the combustion process insofar as the rate of distillation of the volatile matter was affected by the method of firing.*

In the tests conducted with the several arrangements of setting, it was observed, whenever the firing was done by the alternate spreading method, that, although the total period of smoke emission was about the same, the duration of the dense smoke emission was greater than when the coking method of firing was employed. The furnace temperature was also higher when firing alternately. In starting to make the analysis it was assumed that, for any one coal, each arrangement of the furnace imposed a certain limit to its capacity to burn volatile matter; that is, when the rate of distillation reached a certain figure some of the volatile combustible would begin to escape unburned and appear as smoke, even though the supplementary air-admission openings were used. Conversely, when the rate of distillation from a newly charged lot of coal decreased to this critical figure, smoke would cease to appear at the top of the stack.

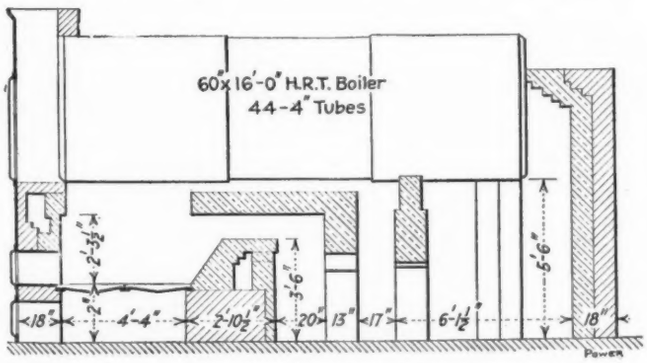


FIG. 4. SETTING WITH DEFLECTION ARCH AND SHELL ABOVE GRATE EXPOSED

In drawing the hypothetical curve of distillation of volatile matter for the spreading and for the coking method of firing, Fig. 5, it was, therefore, assumed that points on both curves represent the critical rate and have ordinates of the same height, and each has an abscissa representing a time interval of two minutes after the firing starts, since ordinarily no smoke was observed with either method of firing two minutes after the firing. The point at the end of the five-minute period (upper curve) was arbitrarily assumed to represent the rate at which the volatile matter was being evolved at the end of the period, and the general form of the curve for the spreading method was taken to be somewhat similar to that shown. The curve representing the conditions in the furnace as a whole, however, is made up of curves representing the distillation on the two sides of the grate, which latter are five minutes behind one another, since this was the firing interval when the alternate spreading method was employed. The form of the resultant curve was, therefore, adjusted to correspond with curves for each half of the grate drawn to represent as nearly as possible the conditions observed during the tests.

The other resultant curve (lower curve, Fig. 5), representing the coking method of firing, was prepared in a simliar

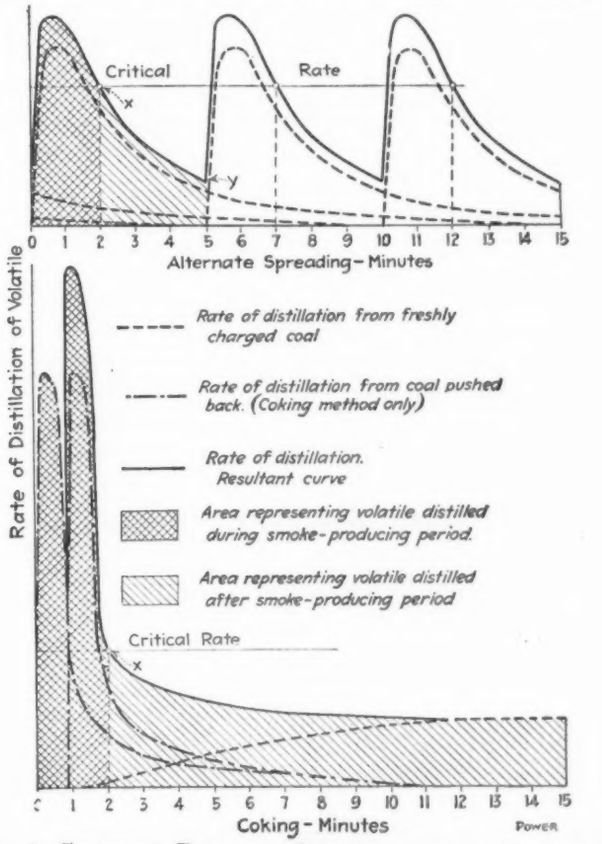

Critical
Rate
x
y
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Alternate Spreading-Minutes
Rate of Distillation of Volatile
Rate of distillation from freshly charged coal
Rate of distillation from coal pushed back. (Coking method only)
Rate of distillation. Resultant curve
Area representing volatile distilled during smoke-producing period.
Area representing volatile distilled after smoke-producing period
Critical Rate
x
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Coking-Minutes
POWER

FIG. 5. SHOWING RATES OF DISTILLATION OF VOLATILE FOR ALTERNATE AND COKING FIRING

*For assistance in making this analysis, acknowledgment is due C. C. Cook, of the Bureau.

way. Whenever this firing method was employed, observations showed that the most rapid distillation of volatile matter occurred immediately after the partially coked coal on the front of the grates was broken up and pushed back. At this time the evolution was at a high rate, but maintained for a short time only. The newly charged coal, of course, began to distill its gassy constituents as soon as it was placed in the furnace, but at a slowly increasing rate which became almost constant during the latter part of the 15-minute firing period.

Under the conditions as indicated by these curves the smoke-producing period would be six minutes out of 15 when the firing was done by the alternate spreading method, and two minutes out of 15 when the coking method of firing was employed. The height of the rate-of-distillation curve during the smoke-producing period in the latter case might seem to indicate that the most dense smoke would be emitted under the coking method of firing. As a matter of fact, ordinarily the most dense smoke was made when the other method was employed, and the explanation probably is that the firing doors, which must necessarily be open for a longer time to fire by the coking method, admit large quantities of air during the time that the most rapid distillation takes place.

While these curves are based on assumption, the truth of which has not been demonstrated, the correspondence with observed conditions would seem to justify the conclusion that they are approximately representative. One point of particular significance is that from the coal fired in any 15-minute period, 61 per cent. of the volatile matter is distilled at a rate above the critical if the firing is by the alternate spreading method, whereas only 41 per cent. is distilled if the other method is employed.

The author's idea in attempting this analysis was that it might make more clear the nature of the problem to be dealt with in hand-fired furnaces, and we may, therefore, stop to consider what the study has revealed. The wide variation in the rate of distillation under either condition of firing, which is shown by the curves, certainly emphasizes the importance of adequate mixing facilities. In the tests mentioned the gas analyses show, in most cases, 60 to 75 per cent. excess air with no CO or other combustibles, but the inability to obtain smokeless combustion proves the inadequacy of the brick arches and piers to properly mix the air and volatile combustible matter at the time of most rapid distillation. The admission of supplementary air through openings at the front of the furnace immediately after times of firing made a marked difference in the smoke emission and demonstrated the effectiveness of the expedient. Some idea of the difference may be gained from Figs. 6 and 7.

The smoky condition prevailed immediately after a firing had been made, without using the air opening at the front; the other view, taken about the same length of time after another firing of approximately the same quantity of coal, was made in a similar way, except that supplementary air was admitted. It should not be inferred, however, that it was possible to prevent smoke emission at all times by this means.

The importance of controlling the rate of distillation and of keeping it as nearly uniform as possible, is also illustrated by the curves. In one case, the volatile matter is being distilled at a rate above the critical for only two minutes out of 15, or about 13 per cent. of the time; in the other case, the distillation at the excessive rate covers a period approximately three times as long. If the same quantity of volatile matter represented by the curves were driven off at a uniform rate, the critical rate for that furnace would not have been exceeded and the combustion would have been smokeless. To obtain this uniformity of rate of distillation in hand-fired furnaces, however, is impossible, although the variations by proper construction and operation of the furnaces may be reduced.

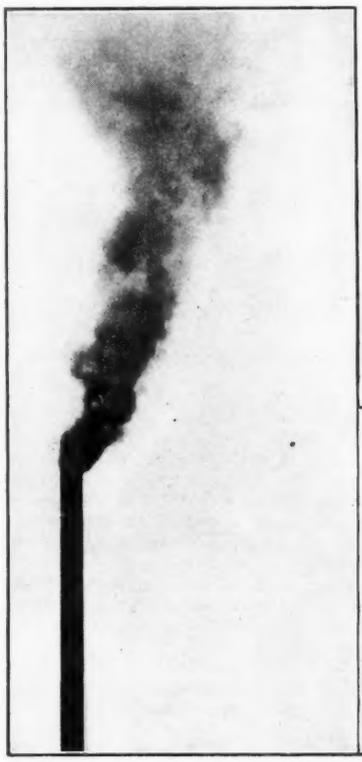


FIG. 6. JUST AFTER FIRING; NO SUPPLEMENTARY AIR USED

FIG. 7. AFTER FIRING; SUPPLEMENTARY AIR USED

PRINCIPAL RESULTS

	Series No.	Auxiliaries Used: None Coking	None Spreading	Air Over Fire Coking	Air Over Fire Spreading	Air Through Bridge Wall Coking	Air Through Bridge Wall Spreading	Steam Jets Over Fire Coking	Steam Jets Over Fire Spreading	Steam Jets and Air Over Fire Coking	Steam Jets and Air Over Fire Spreading
Efficiency of boiler and grate, per cent.	1	55.9	60.0	59.7	62.6	56.0	61.4	57.7	56.4	60.4	58.9
	2	57.1	59.7	59.6	60.4	61.1	61.8	57.0	58.8	60.2	60.8
	3	62.1	60.9	62.6	63.4	62.3	64.5	62.0	61.7	66.1	64.6
	4			57.9	61.6					58.6	62.5
	5			65.7	67.0					68.0	65.5
	6			64.7	64.3					63.0	63.4
Average density of smoke % black	1	4.1	20.0	3.0	15.8	4.0	20.8	7.0	33.6	11.0	27.3
	2	10.4	25.4	11.1	20.0	9.0	16.1	14.3	31.0	9.7	21.2
	3	15.7	23.9	10.8	14.6	7.8	15.8	13.0	28.2	8.0	21.4
	4			4.9	14.0					3.0	11.3
	5			9.8	12.6					4.8	16.5
	6			4.2	20.4					3.8	13.6
Max. mins. of dens smoke, per hr.	1	2.5	14.5	2.0	13.5	2.0	14.5	6.2	30.0	7.5	23.0
	2	10.0	16.5	8.5	18.0	7.0	14.0	10.5	23.5	6.5	16.5
	3	13.5	18.6	7.0	11.0	4.5	8.0	9.0	23.5	6.5	18.0
	4			6.0	17.5					4.0	14.5
	5			6.0	7.0					3.0	11.0
	6			3.5	16.5					3.0	15.0
Flue temp. deg. F	1	601	534	575	536	576	541	561	545	549	556
	2	630	550	581	539	576	555	577	542	587	534
	3	566	561	526	537	549	529	542	526	534	500
	4			588	503					587	563
	5			574	559					526	547
	6			537	563					560	559
Carbon dioxide	1	8.4	11.5	8.0	11.5	8.2	12.3	8.9	12.3	10.0	12.3
	2	9.2	10.7	9.6	10.8	9.3	11.4	8.5	12.6	9.4	11.6
	3	10.8	11.9	11.0	11.1	9.8	12.1	11.0	12.8	10.7	14.0
	4			8.9	10.4					8.4	10.5
	5			10.8	10.4					11.4	11.1
	6			11.6	12.6					10.3	11.6
Draft at breaching	1	0.33	0.20	0.33	0.18	0.39	0.15	0.27	0.17	0.20	0.14
	2	0.30	0.17	0.23	0.18	0.22	0.16	0.24	0.12	0.22	0.13
	3	0.19	0.19	0.18	0.18	0.25	0.17	0.21	0.12	0.17	0.12
	4			0.23	0.18					0.24	0.18
	5			0.16	0.13					0.13	0.12
	6			0.34	0.30					0.41	0.34
Quality of refuse per cent. clinker	1	49	70	52	67	49	72	58	64	39	66
	2	52	58	53	66	55	62	62	70	63	69
	3	63	63	46	58	58	61	56	59	54	64
	4			41	43					32	39
	5			38	50					45	49
	6			35	52					27	55

In any furnace which is to be fired by the spreading method, frequency of firing tends somewhat to reduce the variations in rate of distillation, but the charging of green coal into a hot furnace in a comparatively thin layer on top of hot coals must inevitably result in a rapid distillation of the volatile products. It is, therefore, to be expected that the mixing facilities and the supplementary air must play the principal part in preventing smoke emission if that method is to be used. This statement should not be construed to mean that the rate of distillation will not be affected by the construction of the furnace; in fact, proof that it is so affected was furnished when the change was made from the setting shown in Fig. 3 to that in Fig. 4. The lowering of the furnace temperature, which was accomplished by the removal of part of the arch, made a marked difference in rapidity of distillation and in smoke emission. The effectiveness of structures to mix the gases seems to depend largely upon the sudden changing of the direction of flow of the gases and not upon breaking them up into streams of small cross-section.

The curves under discussion also illustrate the effect of a difference in method of operation upon the rate of distillation in this furnace. From them it is seen that by the use of one method it was possible to keep the distillation below the critical rate most of the time. Further improvement means the changing of the form of the curves so that some of the volatile products now distilled at an excessive rate may be driven off more slowly. The exposure of any water-cooled surfaces to the radiant heat from the fuel beds tends to keep down the temperature of the furnace and of the fuel bed, and hence it lowers the rate of distillation.

An increase in the frequency of firing by the spreading method will decrease the duration of smoke emission after each charging of coal and may decrease somewhat the area above the critical rate line and below the rate of distillation curve, but the variation in rate must still be large under these firing conditions. Inspection of the curve for the other method of firing shows that it is when the partially coked coal is pushed back that the excessive distillation occurs, but if the freshly charged coal could be more rapidly and more thoroughly heated, the curve representing the rate of distillation of this part of the volatile matter would be raised. In this way the proportion of the volatile products distilled at a rate below the critical rate would be increased and the variation in rate of distillation decreased. It is quite possible that a change in the construction of the brickwork at the front end of the furnace, so as to reflect more of the heat from the rear part of the fuel bed onto the green coal in the front, would make possible the accomplishment of the object.

In an earlier part of this paper mention was made of the application of the principles or methods of smoke prevention in mechanically stoked furnaces. Some of the problems of this character are perplexing, but ordinarily these troublesome phases are not encountered unless the installation is made under severe or limiting conditions such as are met in plants operating under heavy loads or those where it has been considered impracticable to set the stokers with the required combustion space. In some of the central stations in the larger cities where, for economic reasons, it is imperative that equipment be operated at maximum capacity during the hours of peak loads, the problem of preventing smoke is particularly difficult. Installations that could easily be operated without smoke under ordinary conditions may, under these circumstances, smoke seriously. It is quite possible that such plants may find it necessary to attack the smoke problem somewhere other than in the furnace, as some have already done.

The analysis of the combustion processes under the test conditions described is based largely upon assumption.

Power in the United Kingdom—At a recent meeting of the Manchester (England) Association of Engineers, Edward G. Hillier stated that the total horsepower in use in the United Kingdom was 10,578,475, nine-tenths of which was provided by steam engines. Steam turbines rated second in the list, gas engines third, and water power fourth.

Electric Power for Farmers—Having contracted with the River Falls Power Co., New Richmond, Wis., for a supply of electricity to be delivered at substations 20 miles apart along its interurban line, the St. Paul Southern Electric Ry. Co. announces that it will furnish current to light villages along the road, which is now under construction, and supply nearby farmers with electricity for light and power. The power company's contract contemplates the construction of hydroelectric plant improvements which will include a reinforced concrete dam 92 feet long across the Kinnickinnic River above Clifton, Wis.

Alaskan Water Power Urged

W. P. Lass, in an address on Mar. 16, in New York City, before the American Electrochemical Society declared that a proper development of the water power in southeastern Alaska would be more valuable than either the gold mines or fisheries.

The greater part of southeastern Alaska, Mr. Lass contended, although undeveloped, unsurveyed and unprotected, has been held in national forest reserves and little attention has been paid by anyone to its development and utilization. The present generation should use efficiently the great water supply of Alaska for power. It is an ever flowing source of power that lost today can never be regained.

Big Southern Power Organization

A $2,000,000 corporation to provide electric power and lighting facilities for the Santa Ynez valley, the northern end of the county and all of San Luis Obispo county, has filed articles of incorporation at Santa Barbara, Calif., being the Midlands Counties Public Service Corporation.

The present place of business is in Los Angeles. The stock is equally divided between common and preferred and the controlling interest has been secured by the incorporators subscribing $1,000,500.

The company has acquired the power plants at Santa Maria, San Luis Obispo, Lompoc and other points, and plans for immediate extensions are being made. The new company is a subsidiary of the San Joaquin Light & Power Co. A. G. Wishon, one of the incorporators in the Midlands concern, is general manager of the San Joaquin company.

Power will doubtless be supplied by the immense plants of the San Joaquin company in the Sierra Mountains.

Coming Meeting of the National District Heating Association

The sixth annual convention of the National District Heating Association will be held in Rochester, N. Y., May 26, 27 and 28, 1914. The program as arranged by the executive committee is substantially as follows:

Tuesday, May 26, 2:00 p.m.
- Welcome Address.
- Response.
- President's Address.
- Report of Secretary-Treasurer.
- Appointment of Nominating Committee.
- Report of the Underground Construction Committee.

Tuesday, May 26, 8:00 p.m.
- Report of Nominating Committee.
- Address—Speaker yet to be selected.
- Address, "Manufacture of Welded Iron and Steel Pipe," accompanied by moving pictures.

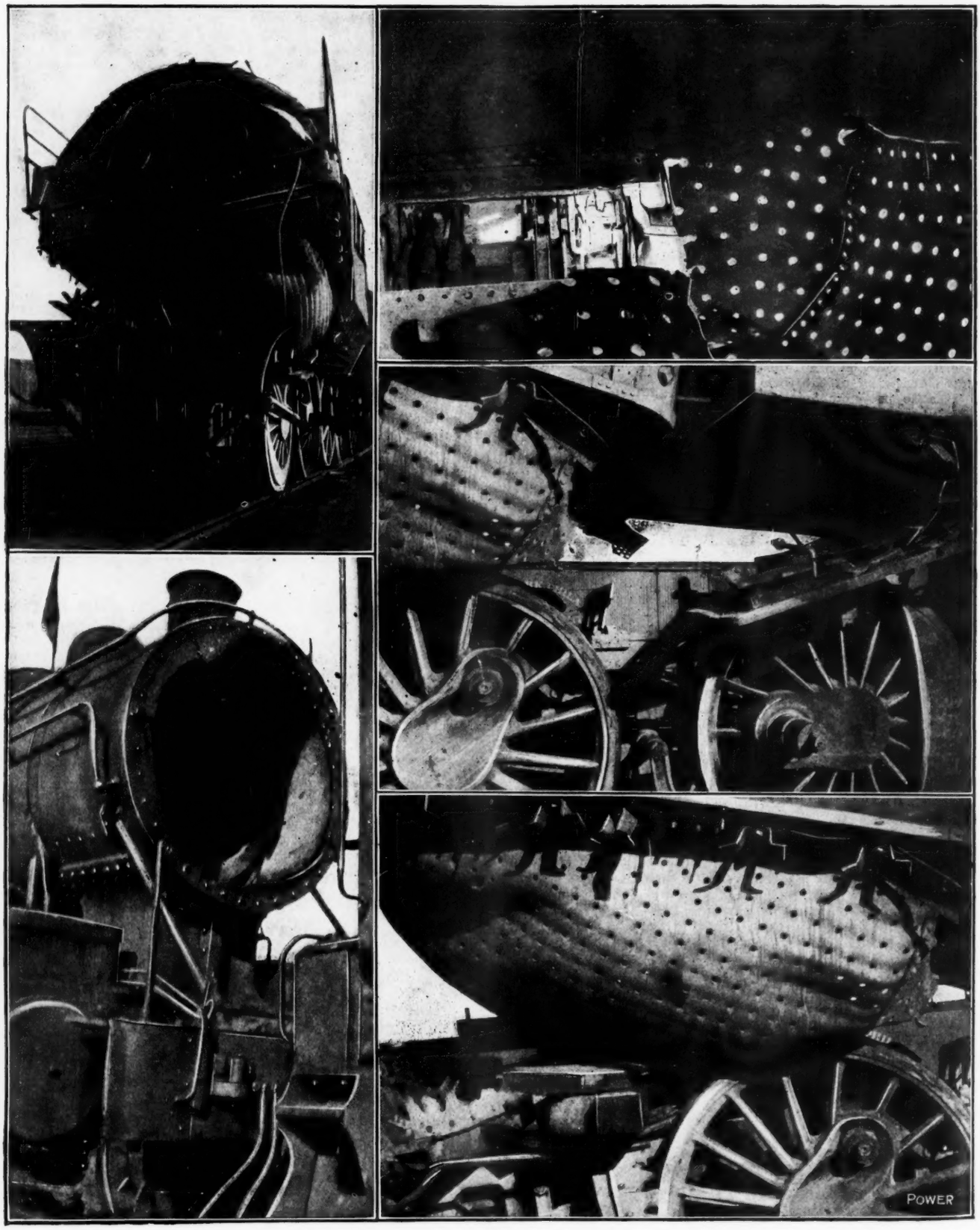
Wednesday, May 27, 9:30 a.m.
- Report of Meter Committee, A. D. Spencer, Detroit, chairman. "Use of Bleeder Turbines in Connection with Steam Heating," R. D. DeWolf, Rochester, N. Y.
- Election of Officers.
- Report of Record Committee, A. P. Biggs, Detroit, chairman.

Wednesday, May 27, 2:00 p.m.
- Discussion Session. The following subjects will be discussed:
- "Hot Water Heating under Forced Circulation," Thos. Donahue, LaFayette, Ind., to open.
- "Expense of Operating Centrifugal Pumps vs. Double Acting Pumps," A. C. Rogers, Toledo, O., to open.
- "Some Effects of Utility Regulation as Affecting District Heating," D. L. Gaskill and H. Almert to open.
- "Effects of Superheated Steam on Heating Systems," Davis S. Boyden, Boston, Mass., to open.
- "District Heating for Small Towns and Cities of 10,000 Population and Under," L. T. Mason, Hornell, N. Y., to open.
- "Heat Losses from Buildings of Latest Construction," H. Byers Holbrook, New York City, to open.
- "Which is More Profitable, To Shut Steam Off at Night or Keep It on Continuously? "E. L. Wilder, Rochester, N. Y. to open.
- "Economic Advantage to the Consumers of Central Station Heating Service Over Individual Heating Plants." N. M. Argabrite Elwood, Ind., to open.

Thursday, May 28, 9:30 a.m.
- Report of Rate Committee.
- "Customers' Steam Heating Systems," H. R. Wetherell, Peoria, Ill.

Thursday, May 28, 2:00 p.m.
- "Commercial Steam Heating in New York City," Geo. W. Martin, general manager of the New York Service Co.
- Report of Educational Committee, D. S. Boyden, Boston, chairman.
- Report of Station Operating Committee, Byron T. Gifford, Grand Rapids, Mich., chairman.

There will be an exhibit in connection with the convention and elaborate entertainment will be provided.



Freaks of a Locomotive-Boiler Explosion

At 4:10 a.m., March 31, a freight locomotive on the Philadelphia & Reading Railroad, carrying 205-lb. pressure, exploded while climbing a heavy grade at Fanwood, N. J. (near Plainfield). The photographs reproduced tell the story in a graphic way. Fortunately no one was killed or seriously injured. The crown-sheet failure was due to low water. The rear and side sheets seem to have held, directing most of the force of the explosion forward.

Recent Court Decisions

Digested by A. L. H. STREET

Nuisance Produced by Sawdust as Fuel—A lumber company using sawdust as fuel in operating a steam power plant is held by the South Carolina Supreme Court to be liable in damages to an owner of nearby property for annoyance and discomfort caused him by partly burned sawdust, transformed into cinders and charcoal blowing upon his premises. (White vs. Halsey Lumber Co., 81 "Southeastern Reporter" 11.)

Establishment of Rates for Public Service—Under a very recent decision of the United States District Court for the district of Arizona, it is held in the case of Bonbright vs. Geary, 210 "Federal Reporter" 44, that a state commission, in fixing rates which may be charged by public service companies, must make the rates sufficiently high to yield a fair return on a reasonable valuation of the company's property employed in affording the service; and that the establishment of rates based upon undervaluation of such property, or upon an omission to value certain property so employed, amounts to an unconstitutional confiscation of property without adequate compensation.

Damages Recoverable for Smoke Nuisance—When a property owner establishes the fact that dense smoke discharged from a manufacturing plant settles on his property to the discomfort of the occupants, he is entitled to recover at least nominal damages, without further proof of injury, according to the decision of the Appellate Division of the New York Supreme Court in the recent case of Gibbons vs. N. Y. C. & H. R. R.R. Co., 146 "New York Supplement" 288. And when he shows that the rental value of his property has been depreciated on account of the nuisance, he is entitled to recover substantial damages, the court holds.

Power Plants as Part of Real Estate—The right of one who installs a power plant in a light manufacturing establishment to enforce a mechanic's lien to secure payment of the contract price was the subject of controversy in the recent case of Northwestern Lumber & Wrecking Co. vs. Parker (145 "Northern Reporter" 964) which was before the Minnesota Supreme Court. In holding that the plant in this instance was subject to lien as a permanent improvement of the land, as distinguished from a removable fixture, the court announced these principles: As between a seller and purchaser, or mortgagor and mortgagee of land, personal property which has been permanently affixed to the real estate becomes a part of the land. But, as between a landlord and tenant, fixtures installed by the latter may be removed during the tenancy, if the removal can be effected without injury to the premises. The right to a mechanic's lien in this case was not defeated by the fact that the tenant, with the landlord's consent but without knowledge of the lien claimant, executed a chattel mortgage to a fourth party, covering the power plant. The court's finding that the power plant became a part of the realty was influenced by the fact that the boiler and smokestack were firmly set in foundations forming part of the building, and that the engine was bolted firmly to the floor.

NEW PUBLICATIONS

ELECTRIC LIGHT AND MOTOR WIRING. By George J. Kirchgasser. Published by the Electroforce Publishing Co., Milwaukee, Wis., 1914. Size 3x5½ inches, 270 pages, illustrated. Price, $1.

A handy little book of vest-pocket size explaining the usual wiring methods such as open wiring, molding, concealed knob and tube, conduit, flexible conduit and armored conductors. These are well illustrated and a variety of electrical fittings is shown.

The first half of the book is devoted to lighting circuits and the second half to motor circuits. Such tables as would ordinarily be required by the electrician or architect are included, and typical wiring problems are worked out. Also, the latest restrictions and requirements of the National Electric Code as applied to wiring systems are considered.

APPLICATION OF POWER TO ROAD TRANSPORT. By H. E. Wimperis. Published by D. Van Nostrand Co., New York. Size 5x7; 130 pages, illustrated. Price, $1.50 net.

The material is drawn largely from a series of lectures delivered by the author before the Finsbury Technical College last year. In contrast to most books on automobiles, there is an absence of descriptive matter, the text following closely that phase of the subject prescribed by the title. Among the items taken up are: Resistance to motion in relation to loads, speeds and wheel diameters; amount of power necessary; loss of power in engine friction and in transmission gear; relation between engine dimensions and gear ratios to the work to be done; and significant points on automobile design. These subjects are treated clearly, and only simple mathematics are employed.

The appendix contains tables and the results of tests showing the relation between size of engine, maker's rating, brake horsepower and R. A. C. rating (which corresponds to our A. L. A. M. rating.)

Although based mostly on English practice, a large part of the text is fundamental and applies equally to American practice. The field for the book is exclusively that of the automobile engineer and designer.

ENGINEERING AFFAIRS

The April meeting of the Isolated Power Plant Association will be held in the Engineering Societies Building, 29 West 39th St., on Monday evening, Apr. 28, at 8:15. The question of extending the New York organization throughout the country will be taken up. Inquiries have come to this association from time to time in regard to the objects of the organization, and it is to be seen from the tenor of the inquiries that other localities are in pressing need of information. The status of the Edison rate case will receive attention at the meeting and also a number of new cases affecting electric rates in New York. Some of them have developed points of considerable importance as bearing upon the general question of rates.

The second annual banquet of the Bliss Electrical School Alumni Association was held April 13, President Louis D. Bliss, of the Bliss Electrical School, Washington, D. C., presided. Among the speakers were H. C. Fleming, of the Pennsylvania Public Service Company, Indiana, Penn.; John W. Ward, general superintendent the Pittsburgh High Voltage Insulator Co., Derry, Penn.; E. M. Kreidler, the Union Switch & Signal Co.; Alexander Weinberg, president Duplex Electric Manufacturing company; James S. Dodds, instructor Carnegie Institute of Technology; E. J. Dovey and G. R. Jennings, Duquesne Light Co.; N. P. Knowles, Central District Telephone Co.; C. A. Batton, J. B. Harris Jr., S. B. Hull, M. B. King, C. A. Purdy, H. E. Renkert, C. E. Smith and C. P. Walker, of the Westinghouse companies.

The annual exhibition of the work of day students of Pratt Institute, Brooklyn, N. Y., will be held as follows: Thursday, Apr. 30, 2 p.m. to 10 p.m.; Friday, May 1, 10 a.m. to 10 p.m.; Saturday, May 2, 10 a.m. to 5 p.m. This exhibition is open to the public and a cordial invitation is extended to all who are interested in industrial and technical education. The students will be engaged at their regular work, and an opportunity will thus be afforded to visitors to inspect the methods, equipment and general facilities for conducting this kind of training, as well as the finished products of the students in the various courses. Pratt Institute is a pioneer in the field of industrial education and for many years has been developing courses of the kind for which there is so strong a demand at the present day. The school offers day and evening courses for both men and women in a great variety of vocational subjects, including fine and applied arts, household science and arts, architectural design and construction, library management, kindergarten training and technical and trade courses for men along many important lines. The work of the School of Science and Technology should prove of special interest to men engaged in technical and trade pursuits. It provides instruction in applied mechanics and machine design, applied electricity, applied chemistry and tanning, machine work and toolmaking, carpentry and building, pattern making, plumbing, foundry and forge work and sheet metal work.

PERSONALS

A. S. Baldwin has accepted the position as manager of works of the Best Manufacturing Co., Pittsburgh, Penn. Mr. Baldwin was formerly general manager of the Alberger Pump & Condenser Co., Newburgh, N. Y., which position he resigned on the first of April.

BUSINESS ITEMS

Owing to the continual growth of its business the Scandinavian Belting Co. will on or about May 1 remove its New York office to 106-108 Reade St.

The Shipley Construction & Supply Co., domestic and foreign agents for the York Manufacturing Co., are now occupying offices in its new building, corner of Columbia and Warren Sts., Brooklyn, N. Y.

The Dearborn Chemical Co. has transferred its southeastern branch office from Birmingham, Ala., to Atlanta, Ga., 1407 Candler Building, where C. H. Everett and J. F. Boutelle, representing the Dearborn company in that territory, will have their headquarters.

F. S. Palmer, the well known engine-stop man, is back with the Locke Regulator Co., of Salem, Mass., as manager of the engine-stop department. Mr. Palmer some years ago had been a representative for the Locke Regulator Co. and his friends will be glad to hear of his return to his old company.

Warren Webster & Co., Camden, N. J., has just published a very interesting booklet on the Webster Vacuum System of Steam Heating. It illustrates many of the largest buildings and hotels in different cities in which this system is installed and is full of valuable steam-heating data. The number of the booklet is B 87h and is mailed on request.

The Ingersoll-Rand Co. has opened a new branch office and warehouse at 1036 Union Oil Bldg., Los Angeles, Calif. W. A. Townsend, formerly manager of the El Paso office, will be in charge. J. D. Foster succeeds Mr. Townsend as manager of the El Paso branch. This company has also opened a branch in the city of Juneau, Alaska, with Frank Carroll in charge. Walter A. Johnston is now pneumatic-tool manager of the Pittsburgh branch, and C. F. Overly of the Cleveland branch.

Among recent sales of "Economy" turbines made by Kerr Turbine Co., Wellsville, N. Y., are the following: Thirteen units for driving pumps, Swift & Co.; six units for driving pumps, Crane Co.; three turbo pumps, Lackawanna Steel Co.; one turbo pump, American Sheet & Tin Plate Co.; 400-hp. unit, Carnegie Steel Co.; 150-hp. belted unit, Bodcaw Lumber Co. Turbo-generators as follows: 500-kw. unit, Coy Paper Co.; 250-kw. unit, Standard Oil Co. (2); 200-kw. unit, Taggart Bros. Paper Co.; 150-kw. unit, Glasgow Electric Light & Ice Co., city of Ravenna (Ohio), and Kerite Insulated Wire & Cable Co.; 125-kw. unit, Ypsilanti Reed Furniture Co.; 100-kw. unit, Gulf Fisheries Co.

G. L. Simonds & Co., 500 Gaff Building, Chicago, Ill., have recently secured contracts for installation of Vulcan soot cleaners from S. F. Bowser & Co., Fort Wayne, Ind.; North Western Penn. Ry. Co., Meadville, Penn.; Duquesne Lighting Co., Brunot's Island Power Plant; Pittsburgh, Penn., 20 cleaners; Mahoning & Shenango Ry. & Light Co., Lowellville, Ohio; Babcock & Wilcox Co., for Cincinnati Water-works; Babcock & Wilcox, for Orrville Water-works, Ohio; Penn Central Light & Power Co., Warrior Ridge, Penn. Also for Williamsburg, Penn., plant; Penn Public Service Co., Phillipsburg, Penn.; U. S. Aluminum Co., New Kensington, Penn; Transue & Williams, Alliance, Ohio; Havana Electric Ry., Light & Power Co., Havana, Cuba; Merchants Heat & Light Co., Indianapolis, Ind.

The A. S. Cameron Steam Pump Works, 11 Broadway, N. Y., has opened branch offices and warehouses in the following cities: Birmingham, Ala., American Trust Bldg., H. M. Perry, mgr. Chicago, Ill., Peoples' Gas Bldg., M. P. Frutchey, mgr. Cleveland, Ohio, Williamson Bldg., W. A. Armstrong, mgr. Duluth, Minn., Providence Bldg., S. H. Hill, mgr. Houghton, Mich., Thos. F. Lynch, mgr. Knoxville, Tenn., Holston National Bank Bldg, L. F. Thompson, mgr. Los Angeles, Calif., W. A. Townsend, mgr. Philadelphia, Penn., Arcade Bldg., Phil. Weiss, mgr. Pittsburgh, Penn., Farmers' Bank Bldg., W. B. Brendlinger, mgr. St. Louis, Mo., 300 N. Broadway, A. A. Bonsack, mgr. Seattle, Wash., Colman Bldg., R. W. Douglas, mgr.

NEW EQUIPMENT

ATLANTIC COAST STATES

The plant of the Deposit Electric Co., Deposit, N. Y., was recently destroyed by fire. Estimated loss, $25,000.

SOUTHERN STATES

Plans are being prepared for the installation of an electric-light plant in Woodland, Ga.

The Nashville Cold Storage & Ice Co., Nashville, Tenn., will purchase four 800-hp. boilers for its plant.

CENTRAL STATES

The installation of a municipal electric-light plant at West Union, Ohio, is under consideration.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance.

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given. For detailed information, write the United States Civil Service Commission, Washington, D. C., or other addresses specified.

JUNIOR ELECTRICAL ENGINEER (Male) $1080-$1500; examination May 20; for vacancy in the Interstate Commerce Commission, and positions that become vacant requiring similar qualifications. Write for Circular 397, Application Form 2039.

POSITIONS WANTED

GRADUATE MECHANICAL ENGINEER, several years' commercial experience on power apparatus, also testing and design; references. P. W. 206, Power.

MECHANICAL ENGINEER, graduate, 28, with practical experience on boiler-room work, ice plant, electric plant and water supply; hustler who can carry out responsibilities seeks permanent position. P. W. 207, Power.

ELECTRICIAN AND MECHANIC with broad experience, installation and operation of hydro-electric, gas and oil engine power plants, high tension transmission; age 30, married, speak Spanish; best of references. Lock Box 10, Shreve, Ohio.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

SPECIALTY MEN in every city calling on power plants to sell our patented pump valves; liberal commissions. George C. Van Vechten Co., 255 Main St., East, Rochester, N. Y.

MISCELLANEOUS

PATENTS SECURED—C. L. Parker, Patents 904 G St. Washington, D. C.

ENGINEERS—Do you want to utilize your exhaust steam for heating or driving purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

AUTOMATIC STEAM ENGINE—25 hp. Brownell, almost new; must move to make room for larger engine. Box 12, New London, Minn.

BOILER—350-hp. water tube, used 30 days; insured 200 lb. steam pressure; cost $3500; price, $1500. Duzets & Son, Hudson Terminal, New York.

FOUR-VALVE RUSSELL ENGINE, one, 14x20, left hand; diameter wheel, 88 in.; face, 18 in.; good condition. Municipal Electric Light Plant, Blessfield, Mich.

DYNAMOS—Two 75-kw. Westinghouse, 125-volt, direct connected Ames automatic engines; $975 each. Duzets & Son, Hudson Terminal, New York.

GENERATORS—Two 75-kw.-Wheeler, 250-volt, direct-connected Harris Fleming engine, with switchboards; $1200 each. Duzets & Son, Hudson Terminal, New York.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

WORTHINGTON PUMPS—Two 20x12x15, in working order (with or without fittings); capacity too small for present demands. One Stillwell open heater. Address John M. King, Superintendent of Lancaster Water-Works, Lancaster, Ohio.

1—1000 KW. FILER & STOWELL; 1—1200 kw. Rice Sargent; 1—600 kw. Allis-Chalmers. Vertical engines complete with generators and condensing plant, etc., and in good operating condition. Call or write for further particulars. Western Electric Co., Purchasing Dept., Hawthorne Station, Chicago, Ill.

NO. 21 STIRLING BOILERS—Three class A, 280 hp. each; one class A No. 24 Stirling Boiler, 320 hp., with Dorrance shaking grates, complete with fronts, drums, framework, no tubes; best condition, 160 lb. pressure, one year's use; stored ready for inspection or shipment. A. E. Staley Manufacturing Co., Decatur, Ill.

BUCKEYE STEAM ENGINES—Two at bargain prices. One 12"x21" 85 hp., 185 r.p.m., 85 lb. steam pressure; flywheel 6' 0" diam. 22" face. One 11"x18" 70 hp., 200 r.p.m., 85 lb. steam pressure; flywheel 4' 0" diam. 14" face; changed to motor drive. Must move at once. Write today. The W. H. Mullins Co., Dept. C, Salem, Ohio.

CORLISS ENGINES—1100 HP—26&42x48 Vilter Cross Compound Corliss Engine, Belt Wheel 18'. 800 HP.—22&32x42 Allis Corliss Tandem Compound, Right-hand, 18' Belt Wheel, both Engines perfect condition. Have to move immediately so make price; each engine $1050 f.o.b. cars, guaranteed excellent condition. Harold R. Wilson Machinery Co., 413 Pine St., St. Louis.